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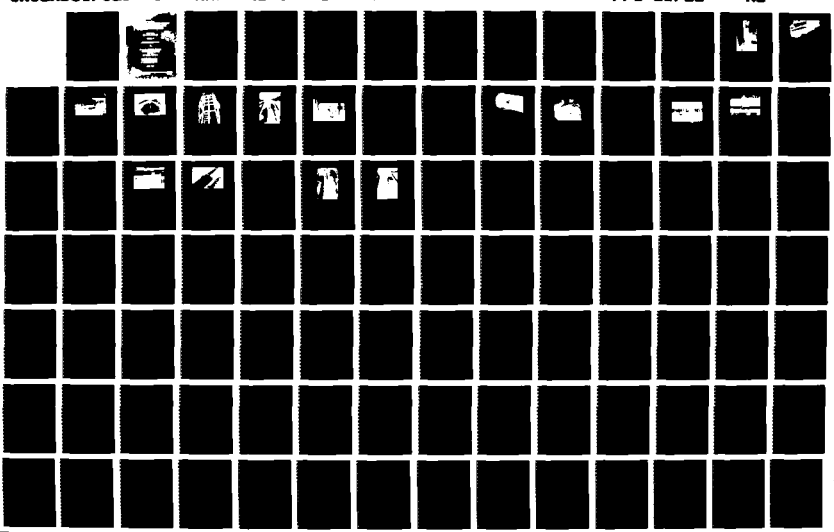

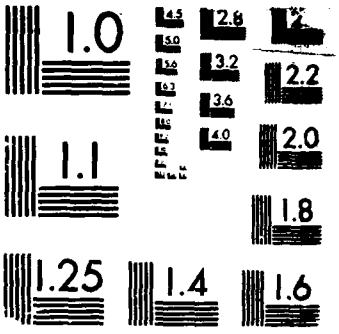
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DETERMINATION OF A PERFORMANCE BASELINE FOR THE NONDESTRUCTIVE EVALUATION OF OFFSHORE PETROLEUM HOSES

FINAL REPORT

SwRI PROJECT 17-7958-837

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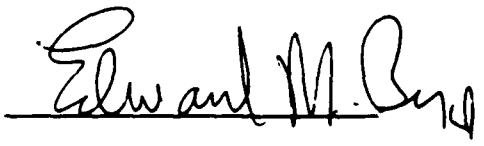

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1. INTRODUCTION

1.1 Background

The Naval Civil Engineering Laboratory (NCEL) has the ongoing task of research directed towards producing a high strength collapsible fuel conduit that can be quickly deployed by operating fleet personnel in support of amphibious invasion forces. Current requirements are for a flexible flowline capable for ship-to-shore delivery of 1 million gallons of fuel within twenty hours over a distance of 4 miles.

NCEL has been evaluating a number of flowline options including hoses of 6, 8, and 10-inch diameters manufactured with a wide variety of materials, fabrication methods, and physical properties. Little in the way of generic models is available for assessing the performance of these products. Similarly, it has been unclear which sort of nondestructive and destructive tests accurately predict the performance of these products in service. These issues have become critical to the Navy in their desire to purchase the best products for the mission and to understand the influences of handling, operational, and environmental loads on the expected lifetime of these products.

1.2 Project Objectives and Tasking

Southwest Research Institute was tasked to assist NCEL in the evaluation of the various hose construction options available, with an objective of gathering data which would further understanding of the generic performance of elastomeric hoses in a flowline application. Specifically, it was desired to subject a variety of hose types to a standard battery of tests in order to gain data for performance comparisons and insight into those nondestructive and destructive tests which are the best predictors of in-service performance. A series of nine structural tests were conducted in order to formulate a data base of performance data for the various types of hoses supplied for evaluation. NCEL provided SwRI with 14 hose samples of 5 different types from 3 different manufacturers for testing. The hose samples ranged from thin-walled, polyester reinforced hose to thick-walled, wire-reinforced hoses. The performance of the hoses in the tests varied widely, providing the desired insight into the effect of hose material and design on specific aspects of performance.

1.3 Report Organization

This final report is organized into four sections and two appendices. Following this introduction is "Test Program Contents" which describes in detail each of the hose samples and the tests performed. A test matrix is provided which is a quick reference to see which hose was used in which test. Abbreviated test procedures for each test used during the project are included in Appendix A.

The third section, "Test Results and Analyses", presents the details of the testing program results and a discussion of the significance of each. Graphs are used to summarize test data. Appendix B contains all of the raw test data.

The report conclusions and recommendations are contained in the fourth section. In addition to this report, a single separate looseleaf binder of original test color photographs is provided.

2. TEST PROGRAM CONTENTS

2.1 Test Matrix

The tests and inspections performed in this program are shown in the test matrix, Table 1. The test procedures were similar to those used in the recently completed test program for the fuel conduit of the Navsea sponsored Offshore Petroleum Distribution System (OPDS). Those procedures, in turn, were derived from the standardized hose tests recommended by the Oil Companies International Marine Forum (OCIMF).

Table 1.
Hose Test Matrix

PROCEDURE

Sample	Acceptance	Hydrostatic	Kerosene/ Vacuum	Burst	Axial Strength	Kink	Torsional Stiffness	Crush
8P12A	X	X		X		X	X	
8P12B			X		X			X
8UA12A	X	X		X		X	X	X
8UA12B	X		X		X			
8UA10	X	X			X			
6UA30	X	X	X	X		X		
6UA12	X				X		X	X
6UF10A	X		X					
6UF10B	X				X			X
6UF20	X	X		X		X	X	
6AW12	X		X		X			
6AW6	X	X		X				
6AP12	X		X		X			
6AP6	X	X		X				

Each of the fourteen hose samples was marked with a unique serial number prior to testing. The numbering scheme is explained below in section 3.1 of this report.

The characteristics of the test samples are summarized in Table 2 below.

Table 2.
Test Sample Characteristics

Hose Sample	Length (feet)	Manufacturer and Type	Couplings/ End Fittings
8P12A/B	12	Pirelli	ANSI 300 Flanges
6UF20	20	Uniroyal Manuli Float/Sink	Hydrasearch Split Clamp Threaded Flange
6UF10A/B	10	Uniroyal Manuli Float/Sink	Hydrasearch Split Clamp Threaded Flange
6UA12	12	Uniroyal Manuli ACP	ANSI 300 Flanges
6UA30	30	Uniroyal Manuli ACP	ANSI 300 Flanges
8UA12A/B	12	Uniroyal Manuli ACP	ANSI 300 Flanges
8UA10	10	Uniroyal Manuli ACP	Hydrasearch Repair Coupling/ ANSI 300 Flanges
6AW6	6	Angus	Angus Split Clamp/ ANSI 300 Flanges
6AW12	12	Angus	Angus Split Clamp/ ANSI 300 Flanges
6AP6	6	Angus	Angus Split Clamp/ ANSI 300 Flanges
6AP12	12	Angus	Angus Split Clamp/ ANSI 300 Flanges

2.1.1 Note on Inherent Test Limitations

Ideally, it is desirable to perform tests to determine the properties of the hose carcass construction alone, independent of any end effects due to couplings, effects of sample length, or other

factors. As a practical matter, however, hoses must be terminated with couplings in order to contain pressure and to provide attachment points for applying external loads. Hose lengths must also be appropriate to test equipment and facilities which are practical in scale and expense.

The reality of hose testing is that test samples are really hose systems, consisting of the hose and the hose termination or coupling device. Every attempt was made during the testing program to eliminate the effects on test performance of coupling type and sample length. In some tests, however, failure occurred not in the hose carcass, but in the coupling, or as a result of the attachment method of the coupling. In such cases, the data has been appropriately noted. Caution must be exercised when evaluating results and making comparisons between hose samples which failed in the carcass, and those which failed due to the coupling since the samples provided for testing were terminated with a variety of coupling types.

2.2 Test Descriptions

There follows a brief description of each of the inspections and tests, together with the rationale for inclusion of the test or inspection in the testing program. Abbreviated procedures used for each test are included in Appendix A.

2.2.1 Acceptance Inspection

An acceptance inspection was performed on each sample before any further testing. The acceptance inspection consisted of an external inspection to document the initial dimensions and condition of the test sample before exposure to any external loads. The inspection data thus established a base line of dimensions and conditions permitting quantitative evaluation of the sample's response to the various test loads. The inspection was performed using measuring tapes and still photographs.

2.2.2 Hydrostatic Test

The purpose of the hydrostatic pressure test was to determine the structural integrity of each sample under internal pressure equal to the designed maximum pressure.

The test sample was filled with water and pressurized according to a time vs. pressure schedule. Dat , was taken for sample elongation while under pressure and compared to the unpressurized length for calculation of temporary and permanent elongation. Because of difficulties in obtaining a seal between the Angus hoses and the Angus couplings, the Angus samples were tested while suspended vertically with a 650 pound weight hanging from the lower coupling. This procedure was necessitated by the unique design of the Angus coupling, which is tapered and designed to seat under tension. The photograph of Figure 1 shows sample 6AP6 undergoing the hydrostatic test.

Figure 1.
Hydrostatic Testing of Sample 6AP6

2.2.3 Kerosene Test

The kerosene test was designed to reveal any material incompatibility between the sample inner tube and a highly seeking, low viscosity petroleum fluid. The test also reveals any manufacturing flaws such as cracks, delaminations, or punctures in the inner tube.

For the test, the samples were pressurized with kerosene for six hours at the operating pressure appropriate for each hose, followed by twelve hours pressurized to one half of the operating pressure. Kerosene forced into hose carcass flaws under pressure then typically causes blisters or obvious delaminations. Immediately upon completion of the kerosene test, the samples were subjected to the vacuum test, which served to "develop" the kerosene test, revealing any kerosene penetration into the carcass or nipple area. The photograph of Figure 2 shows samples 8P12B and 8CA12B during the kerosene test.

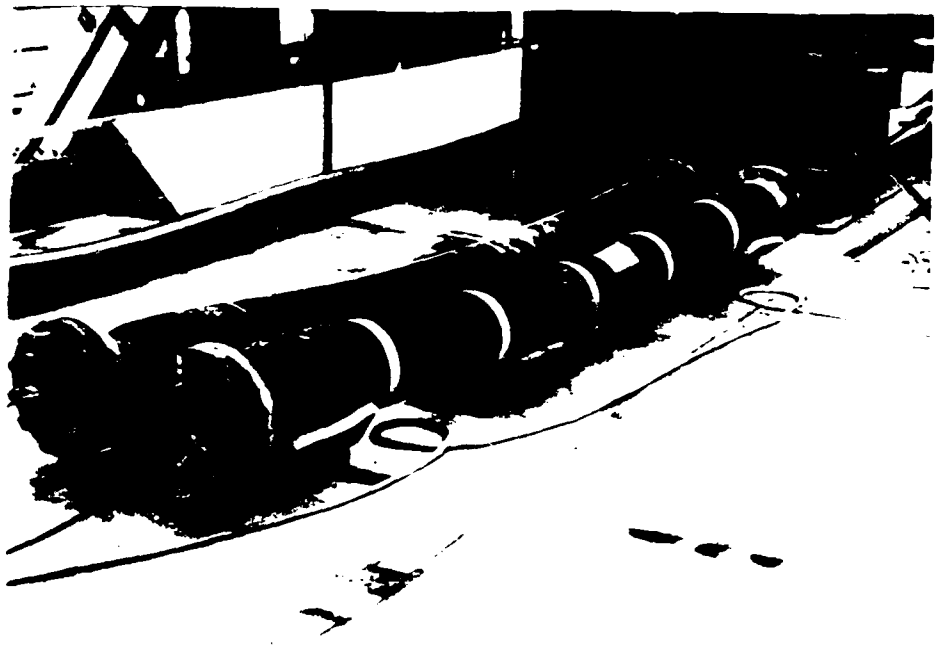


Figure 2.
Kerosene Test in Progress

Because of the coupling difficulties previously mentioned, the Angus samples were kerosene tested vertically with a weight hanging from the lower coupling to aid in sealing the coupling to the hoses. A leak proof, pressure holding seal could never be obtained on the Angus samples, so the kerosene test was modified to simply fill and soak the hoses with kerosene.

2.2.4 Vacuum Test

The vacuum test immediately followed the kerosene test. The purpose of the vacuum test is to draw any penetrated kerosene back into the hose bore where it can be easily observed. Following the kerosene test, each hose sample was completely drained and dried, so that any fluid reappearing during the vacuum test could be interpreted as having been drawn out of cracks, holes, or other flaws in the construction. The sample was then fitted with clear acrylic blind flanges equipped with fittings to draw a vacuum on the hose bore. Once under a vacuum of 15 inches of mercury, the hose bore was examined for the presence of kerosene by using a strong light to provide illumination through the clear flanges. If carcass penetration by the kerosene has been severe, delamination can result and the inner tube will often collapse under vacuum.

2.2.5 Burst Test

The purpose of the burst test was to determine the maximum pressure carrying capability of each sample. The sample was pressurized to the maximum recommended hose design pressure; or 1.5 times the hose operating pressure, whichever was greater; and held for 15 minutes. After the hold period, the pressure was rapidly but steadily increased until burst occurred.

2.2.6 Axial Strength Test

Axial strength testing consisted of two parts. First, the axial stiffness of each sample was determined by measuring the amount of elongation for various loads up to 25,000 pounds tension for all samples except the Pirelli sample, which was pulled to only 15,000 pounds. The Pirelli sample demonstrated much higher elongation than the other samples, and the loads during this part of testing were limited to avoid damaging the hose.

The second part of the testing was a determination of ultimate tensile strength. In this part of the test, the samples were pulled steadily and continuously until failure.

The tests were performed in the SwRI Hose Tension Test Machine, capable of 215,000 pounds tension using a long stroke 10-inch hydraulic cylinder. The machine can accommodate sample elongations of 5 feet and is designed for tension sample initial lengths of 12 feet or less. Figure 3 shows sample 8UA12A undergoing the axial strength test. Sample elongation was measured with a steel tape measure during the axial stiffness portion of the test, and with a string potentiometer during the ultimate tensile strength portion.

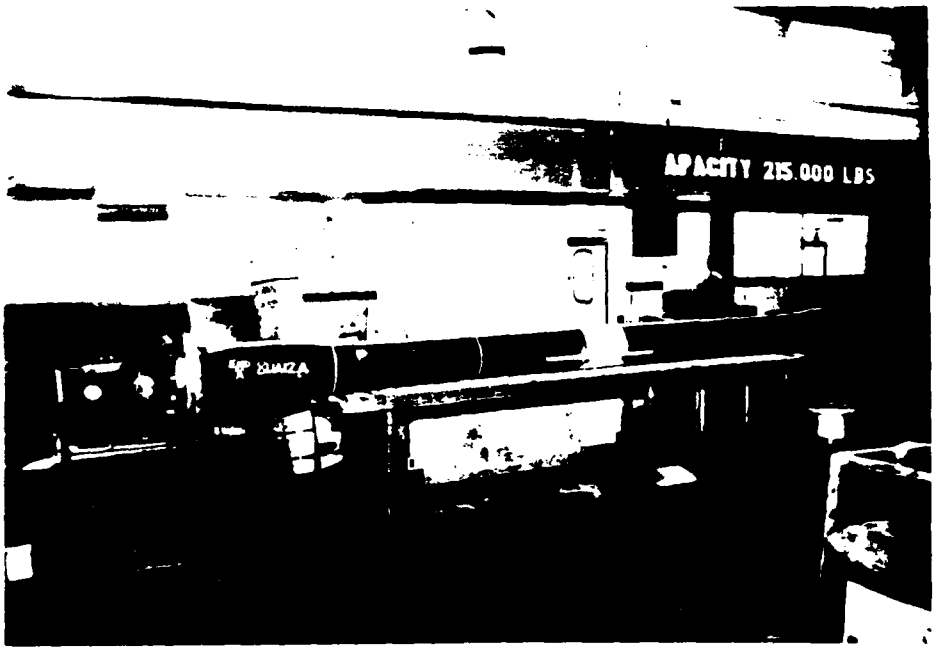


Figure 3.
Axial Strength Test of Sample 8UA12A

2.2.7 Bending Stiffness and Kink Test

The purpose of the kink test was to determine the minimum radius of each sample before kinking and its ability to withstand kinking without structural degradation. Originally, it was proposed to perform the tests using the SwRI developed logarithmic spiral kink test apparatus. For reasons explained in the "Test Results and Analyses" section below, this method had to be abandoned in favor of the more conventional method, in which the two ends of the sample are drawn together until a kink is formed, as illustrated in Figure 4. In some instances it was necessary to pass one end over the other to induce the kink. After kinking, the bending radius was measured and the kink location noted.

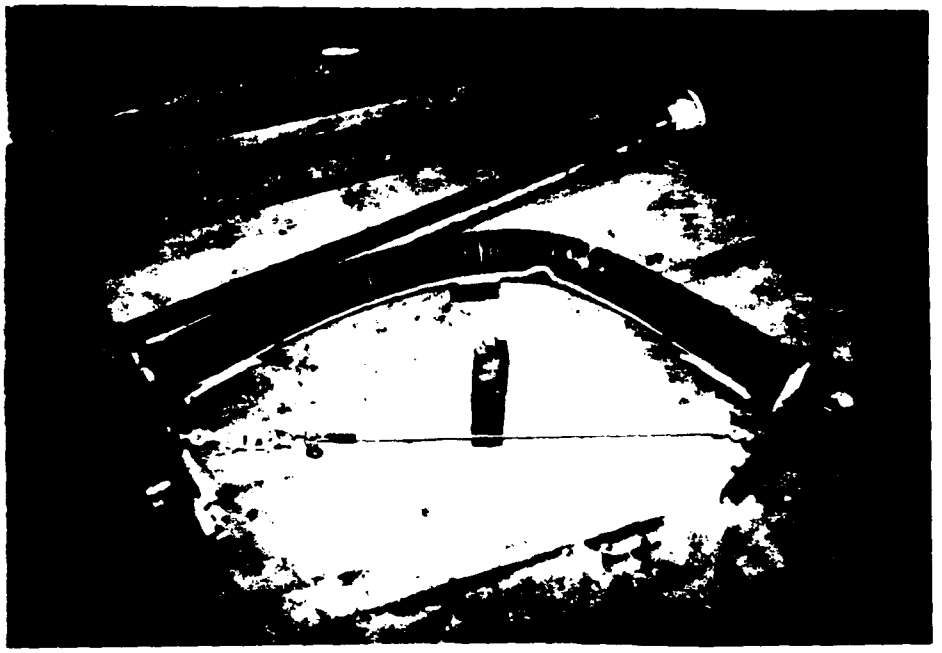


Figure 4.
Kink Test of Sample 8UA12A

2.2.8 Torsional Stiffness Test

Torsional stiffness tests were conducted to obtain torsional stiffness data for each sample. The torsional stiffness is an important property necessary to understand the twisting behavior of hoses. Two SwRI developed test machines, the Hose Torsion Tower and Horizontal Hose Torsion Tank, were used for the testing.

The first machine, the SwRI Hose Torsion Tower, measures the torsional stiffness of vertically suspended samples. Its main feature is a 50-foot tall latticed tower with square cross section, as shown in Figure 5.

Figure 5.
SwRI Hose Torsion Tower

The open area in the middle of the tower is approximately 6 feet by 8 feet. At the centerline of the tower on the base plate is mounted a 3,000 ft-lb capacity hydraulic rotary actuator. The upper end of the test sample is attached to a moveable cross beam in the tower and the lower end is attached to the rotary actuator by means of a slip joint which transmits torque but allows free movement in the axial direction to accommodate sample foreshortening under torsion. A scale on the rotating head of the actuator permits reading of the angle of twist of the sample.

The second machine, the Horizontal Hose Torsion Tank, measures the torsional stiffness of horizontal samples, floating in water. It is a frame and water tank assembly as shown in Figure 6.

Figure 6.
Horizontal Hose Torsion Tank

At one end, the floating sample is fixed to the frame. At the other end, a special flange is fitted to which a central shaft is attached. The shaft passes through two bearing plates attached to the frame, which permit free rotation and axial sliding of the shaft, but constrains the lateral movement of the sample as it is twisted. Torque is applied by a cable passing over a curved shoe/moment arm assembly attached to the special flange at the live end of the hose. A scale on the moment arm assembly indicates the angle of twist of the sample.

Each of the test samples were equipped with blind flanges with pressure and vent taps permitting internal pressurization during testing.

2.2.9 Crush Test

Crush tests were performed to measure the amount of residual deformation induced in each sample by a crushing load. SwRI's Tinius Olsen tensile testing machine with a 0.25-inch diameter crushing ram was used for the tests. The test apparatus is shown in Figure 7.

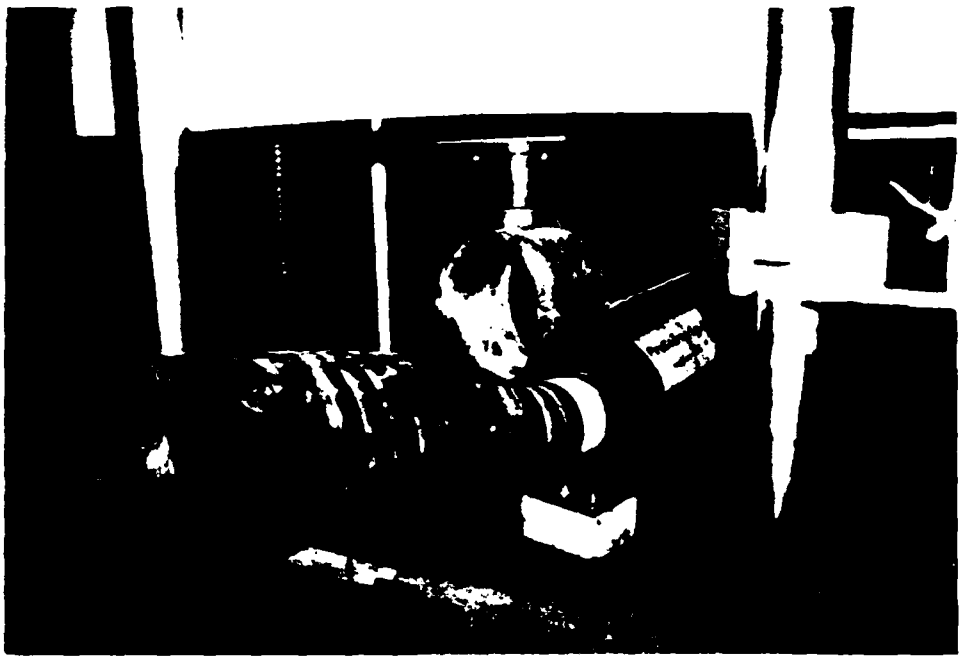


Figure 7.
Crush Test in Progress

Due to size limitations of the machine, 48-inch long unterminated test samples were used. Each specimen was crushed from 10 to 100 percent of its original inside diameter in 10 percent increments. At each increment the residual deformation was measured after 1 minute of relaxation.

3. TEST RESULTS AND ANALYSES

3.1 Acceptance Inspections

Acceptance inspections were performed on the test samples prior to starting the testing program. Because the Angus hose samples were provided in 20-foot, unfinished lengths with one set of couplings; they were cut, assembled, and inspected just prior to use.

As part of the inspection each sample was measured, photographed, and assigned a unique serial number. The assigned number was determined by using the nominal diameter of the hose (6 or 8 inches), the first letter of the manufacturer's name (Uniroyal, Pirelli or Angus), a letter corresponding to the hose type ("A" for Advanced Collapsible Pipe (ACP) hoses, "F" for float/sink hoses, "P" for the polyester prototype, etc.), and the nominal length. Finally, where two samples were identical, the letter "A" or "B" was appended to identification number. For example, one of the 8-inch diameter, Uniroyal, ACP type, 12-foot long hose samples was assigned the serial number 8UA12A, the other 8UA12B.

No significant flaws were noted in the samples and all were accepted for further testing.

3.2 Hydrostatic Tests

Hydrostatic tests were conducted on samples 8UA12A, 8UA10, 6UA30, 6UF20, 8P12A, 6AP6, and 6AW6. All except 6AW6 successfully passed the hydrostatic tests. Sample 6AW6 burst during the first pressurization cycle at 89 percent of its hydrostatic test pressure (see "Burst Tests" section for more information). The following table summarizes the elongation behavior during hydrostatic testing.

Table 3.
Hydrostatic Test Results

Hose Sample	Test Pressure (psi)	Elongation at Pressure (%)	Residual Elongation (%)
8UA12A	1,066	0.13	-0.04
8UA10	1,066	-0.20	0.05
6UA30	1,066	-0.97	0.03
6UF20	600	1.64	-0.05
8P12A	600	-0.56	0.17
6AP6	325	1.65	0.08

In general, the positive or negative elongation of the sample can be explained on the basis of the lay angle of the reinforcement plies. It can be shown mathematically that the neutral lay angle for hose reinforcement plies to resist internal pressure is 54.736 degrees. In other words, reinforcement plies laid at an angle of 54.736 degrees to the axis of the hose result in equivalent axial and hoop load components in the hose. Under these conditions, the hose will neither foreshorten nor elongate under internal pressure. If the lay angle is greater than the neutral angle, the hose will elongate under internal pressure. If the lay angle is less than the neutral angle, the hose will foreshorten under internal pressure. It can be seen that under combined axial and hoop loads, the lay angle of the reinforcement will always tend towards the neutral angle, causing either elongation or foreshortening of the hose.

With this as a basis, the data in Table 3 can be interpreted properly. The very small elongations observed show that all of the hoses have primary reinforcement very close to the neutral angle. The residual elongation after pressurization is a result of many factors including the tension placed in the reinforcement plies during manufacture, the vulcanization process, and the viscoelastic properties of the materials of hose construction. Residual elongation after pressurization is often used as a quality control check for hoses. Geometric stability of hoses is a desirable feature, and the small values of residual elongation for all hose samples can be interpreted to mean that they were generally well made and that their shape is stable. Although the residual elongation is used sometimes as a figure of merit of a particular hose, it is, in and of itself, not definitive. A high residual elongation after pressurization is cause for concern, however, a low residual elongation does not necessarily mean that the hose is fit for a particular application.

3.3 Kerosene Tests

Kerosene tests were conducted simultaneously on samples 8UA12B, 6UF10A, 6UA30, and 8P12B. All samples passed with the exception of 6UF10A which burst after 30 minutes at 600 psi. The sample failed in a straight, axial tear starting approximately 1 inch from the inside edge of the end B coupling (see Figure 8).

Figure 8.
Kerosene Test Failure of Sample 6UF10A

Samples 6AW12, and 6AP12 were tested individually due to the limited number of couplings and the different test procedure. Recall that the Angus samples could never be made leak proof, so they were tested by filling with unpressurized kerosene. No damage to the hoses was found after 24 hours of kerosene exposure.

The premature failure of sample 6UF10A is most unusual, especially in light of the successful hydrostatic test of the similarly constructed 6UF20. Although an extensive autopsy of the failure was not performed, it seems reasonable to conclude that the failure was due to kerosene penetration, rather than pressure alone. Supporting this argument is the 30 minutes it took for the sample to fail. What remains unknown is whether that particular hose type has a design flaw, or if the particular sample tested contained a flaw in the tube which permitted kerosene penetration resulting in failure.

3.4 Vacuum Tests

Samples 8P12B, 6UA30, and 8UA12B were subjected to the vacuum test immediately following the kerosene test. Each sample passed the test without incident. Because samples 6AP12 and 6AW12 are "lay flat" type hoses having no cross-sectional rigidity, they were not subjected to the vacuum test.

3.5 Burst Tests

Burst tests were conducted on samples 8UA12A, 6UA30, 6UF20, 8P12A, 6AW6 and 6AP6. Sample 8UA10 was not subjected to the burst test since it was desired to use this sample also to gather axial strength data.

As previously mentioned, sample 6AW6 actually burst during the hydrostatic test. At approximately 60 percent of the hydrostatic test pressure, the end fitting separated from the hose. The fitting was re-attached and the sample re-tested. The hose failed a second time by tearing at the fitting at 487 psi, 89 percent of the hydrostatic test pressure. Figure 9 shows the failed sample 6AW6.

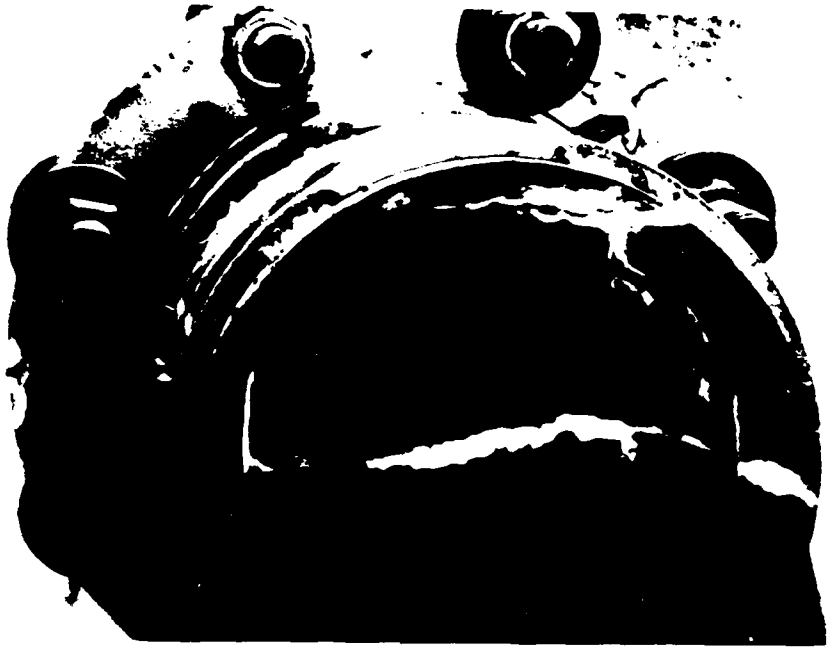


Figure 9.
Burst Failure of Sample 6AW6

The probable cause of this failure is the severe stress concentration in the hose carcass caused by the pinching action of the Angus fitting. The problems with the Angus hose fittings have already been mentioned in relation to sealing. The failure in this test further points out the inadequacy of the Angus fitting design. Since none of the more robust Hydrasearch fittings were sized to fit the Angus hoses, and no other couplings were available, it was impossible to determine the ultimate burst strength of the carcass of Angus sample 6AW6.

The results of the burst tests are given in Table 4 below, ranked in order of decreasing burst pressure.

Table 4.
Burst Test Results

Hose Sample	Predicted Burst Pressure (psi)	Burst Pressure (psi)	Failure Location
8P12A	900	2,159	Carcass
6UA30	1,600	~1,600 (1,836)	Coupling
8UA12A	1,600	1,695	Carcass
6UF20	900	797	Carcass
6AW6	825	487	Coupling
6AP6	500	464	Carcass

The burst failures occurred in two locations, the coupling and the carcass. Coupling failures are failures due to the coupling, either by physical separation of the coupling from the hose or by failure of the carcass plies at the coupling/hose interface. Carcass failures occur away from an end fitting and are the desired failure mode in a well-built hose.

Samples 6AW6 and 6UA30 experienced coupling failures. Sample 6AW6 failed due to tearing at the B end coupling. This failure occurred at lower than expected internal pressure and is probably not indicative of the actual burst strength of the carcass. Sample 6UA30 exhibited ply failure at the coupling/hose interface. Sample 6UA30 was terminated with a built-in steel nipple with an ANSI Class 300 flange attached. At approximately 1,600 psi, the inner carcass layers failed at the inside edge of the end A nipple, causing a large fluid-filled blister on the hose. The hose continued to contain liquid as the pressure was raised, though the blister size increased dramatically. The outer plies finally burst at 1,836 psi. The initial failure is probably indicative of the true carcass burst strength, even though failure did not occur away from the nipple as desired.

Samples sUA12A, oUF20, sP12A, and oAP6 experienced carcass failures of two types: axial tears, and "X" tears. A correlation between the shape of tear and the lay angle of the reinforcing plies was observed. Samples oUF20 and oAP6, both containing layers of straight (0 degree lay angle) reinforcement plies, failed with axial tears (see, for example, Figure 10); while samples sUA12A and sP12A, both with a balanced reinforcement design, failed with "X" tears (see Figure 11).

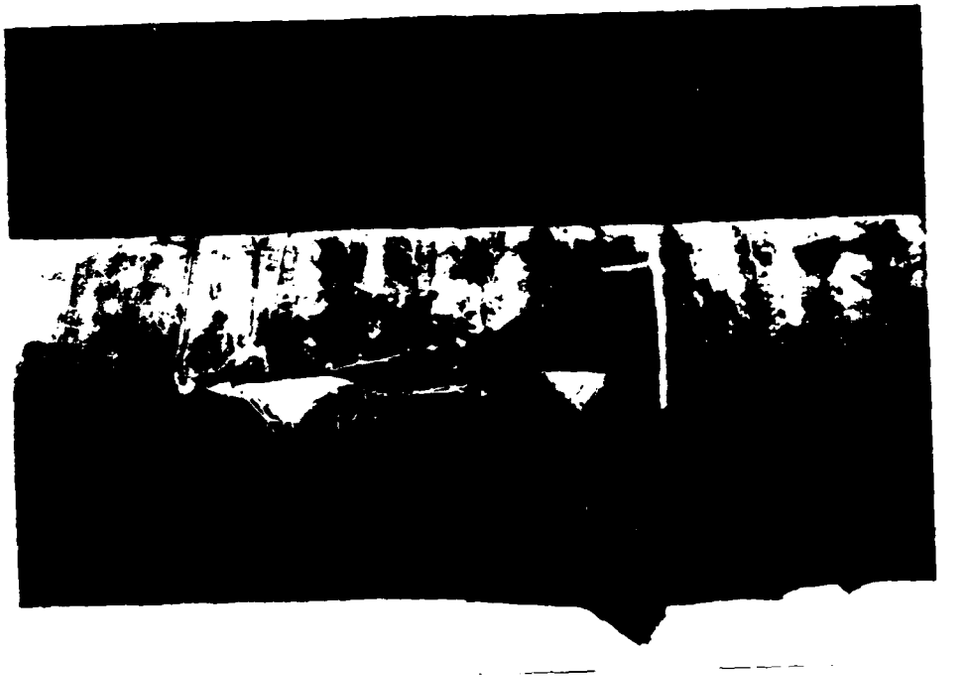


Figure 10.
Axial Tear From Burst Test

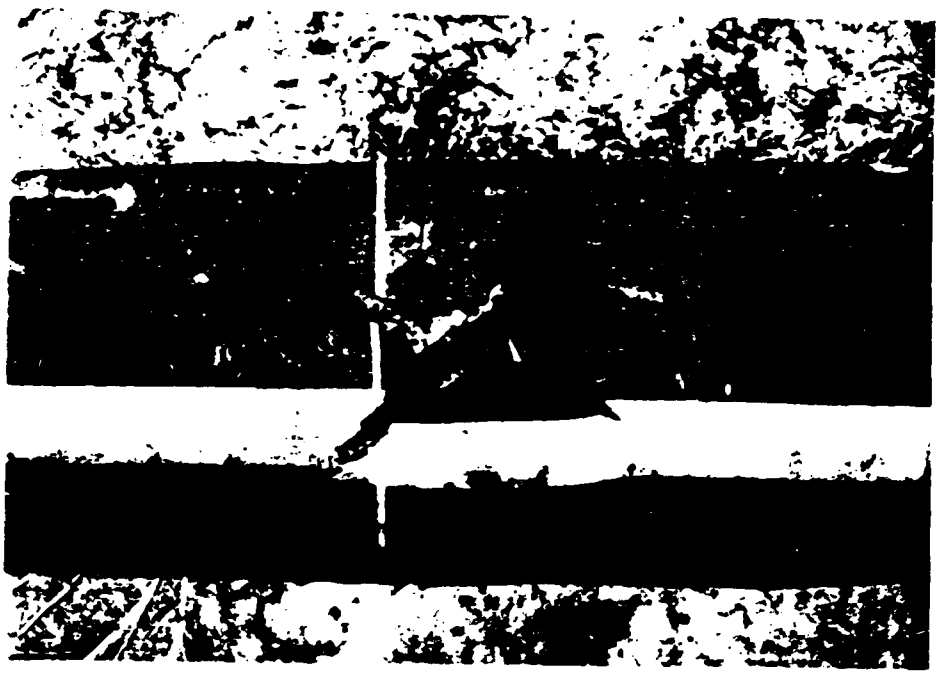


Figure 11.
"X" Tear From Burst Test

3.6 Axial Strength Tests

3.6.1 Axial Stiffness Measurements

The first part of the axial strength test was a measurement of the axial stiffness of each hose. This consisted of taking elongation measurements at incremental loads up to 25,000 pounds tension for all hoses except the Pirelli sample, which was only pulled to 15,000 pounds tension due to its extreme elongation characteristics.

Figure 12 presents the results of the axial stiffness measurements in the form of a graph of wall stress versus percentage free length elongation. The wall stress is the engineering stress in the hose wall calculated by dividing the axial force by the original wall cross-sectional area. The free length of the hose is the total length minus the length of the couplings or built-in steel nipples. The free length is that part of the hose which is actually free to elongate, the coupling or nipple length being rigid and fixed.

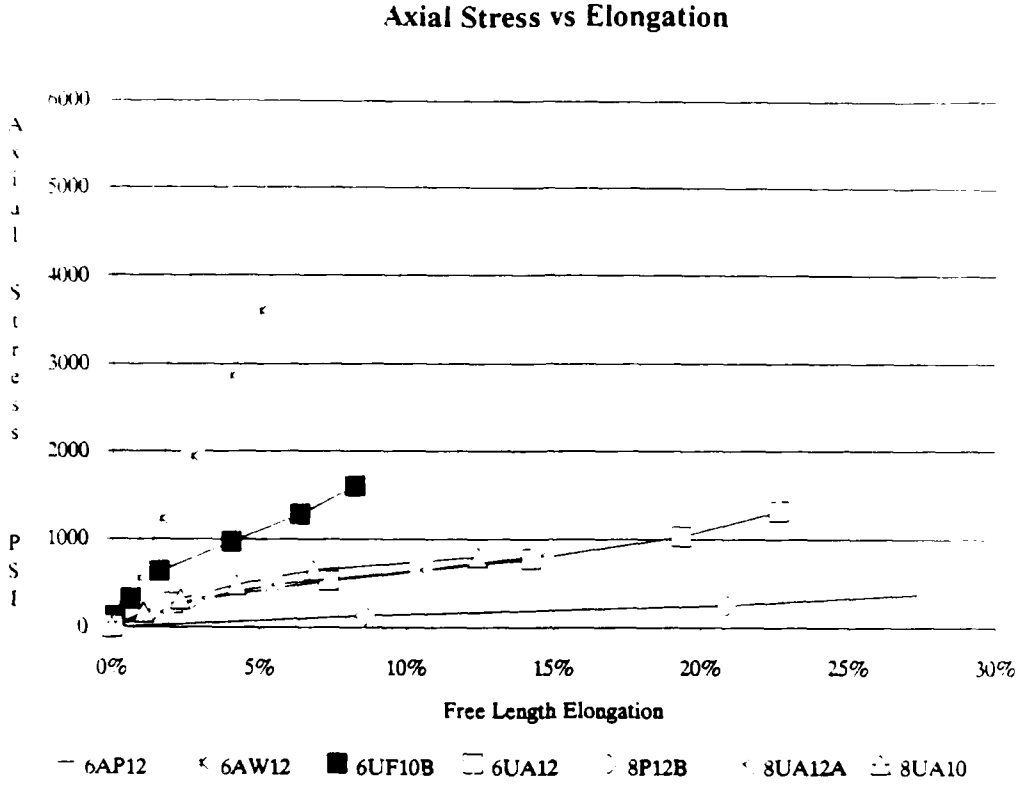


Figure 12.
Axial Stress vs. Elongation Results

Note that the maximum stresses plotted in Figure 12 are not failure stresses, but the stresses corresponding to 25,000 for all samples except 8P12B, whose final data point is for 15,000 pounds tension.

The wide spread in observed axial stiffnesses is explained by the different materials and methods of hose construction represented in the test samples. Figure 13 illustrates the stress vs. elongation performance envelope which can be expected by varying methods of construction.

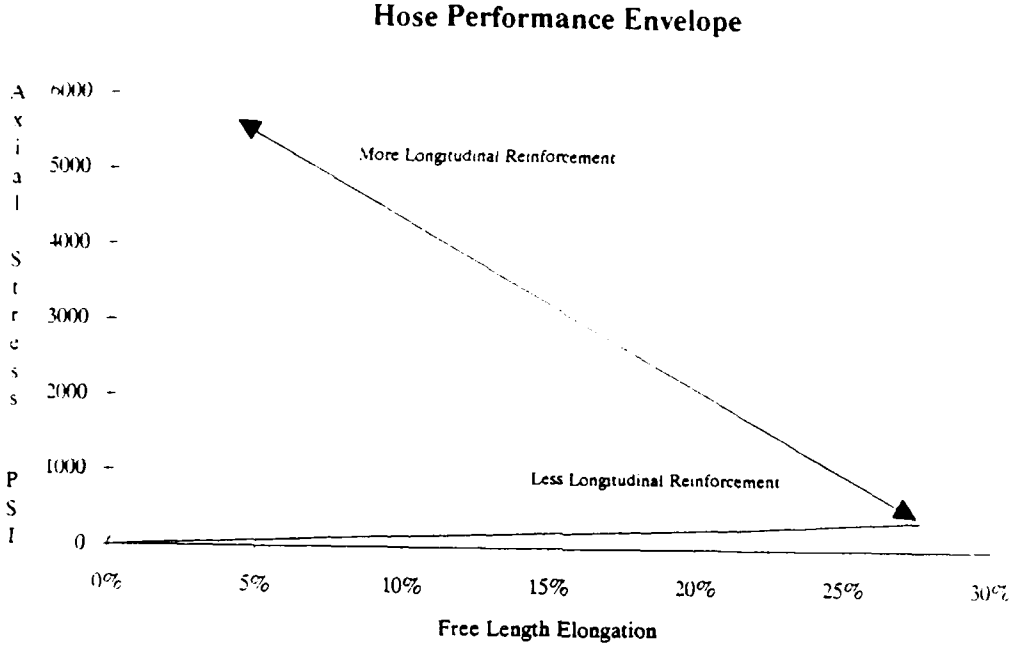


Figure 13.
Axial Stiffness Performance Envelope

3.6.2 Ultimate Tensile Strength

Axial strength tests were performed on Uniroyal Manuli samples 6UF10B, 6UA12, 8UA12B, and 8UA10; Pirelli sample 8P12B; and Angus samples 6AW12 and 6AP12. The table below summarizes the results of the axial strength tests, ranked in order of decreasing ultimate stress.

Table 5.
Axial Strength Test Results

Sample	Predicted Axial Strength (lbs)	Axial Strength (lbs)	Ultimate Stress (psi)	Ultimate Free Elongation (%)
6AP12	47,000	32,936	12,916	--
6AW12	44,000	34,592	8,605	9.3
6UF10B	55,000	54,627	3,466	14.4
8UA12B	80,000	100,073	3,427	35.7
8P12B	55,000	119,969	3,030	41.2
6UA12	80,000	52,657	2,769	30.5
8UA10	80,000	78,740	2,684	36.6

The two Angus samples were both the stiffest axially and also had the highest values of engineering wall stress at failure. Samples 6AP12 and 6AW12 ruptured energetically at stress levels of 12,916 psi and 8,605 psi, respectively. Both hoses separated into two sections at failure. The higher stress levels at rupture are understandable considering that proportionally more of the wall area is devoted to reinforcement in the Angus samples than is the case in either the Uniroyal Manuli or Pirelli designs. It is also interesting to note that the Angus type fittings, which performed so poorly in pressure containment, also caused problems during a tension test by slipping off the hose causing the test to be restarted.

The Uniroyal Manuli float/sink sample 6UF10B had much greater axial stiffness than the Pirelli or Uniroyal Manuli ACP samples, and showed roughly equivalent engineering wall stress capacity as the ACP construction. The sample ruptured energetically at 54,627 pounds axial force at the inner edge of the end B split clamp. All plies failed simultaneously with the conduit separating into two sections.

The Uniroyal Manuli ACP samples, 8UA12B, 8UA10, and 6UA12 displayed higher axial stiffness than the Pirelli sample, and engineering wall stress capacities spanning the Pirelli performance. Samples 8UA12B amd 6UA12 failed in the carcass with the polyester reinforcing plies rupturing suddenly but with the inner tube remaining intact (see Figure 14). Both tests were continued in an effort to rupture the inner tube, but in each case it continued to elongate under low load to the stroke limit of the test machine. The considerable spread in values of engineering wall stress at failure for the Uniroyal Manuli ACP samples (2,769 psi to 3,427 psi) cannot be readily explained. Among the possibilities are slight differences in sample manufacture and inherent scatter in the test data.

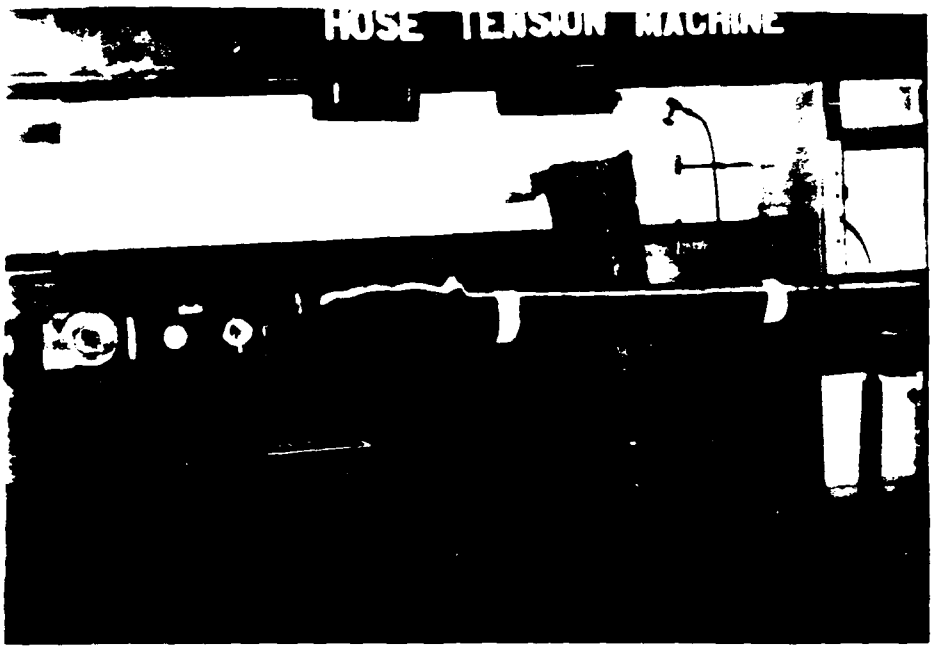


Figure 14.
Distortion in Pirelli Sample During Tension Test

Pirelli sample 8P12B had the largest amount of free length elongation per unit stress (lowest axial stiffness) and a moderate wall stress capacity. At approximately 70,000 pounds of axial force, the sample's steel reinforcing and nipple binding wires began to break and protrude through the outer cover. This constituted an operational failure, even though separation of the carcass had yet to take place. The severe distortion in the hose profile in the nipple area due to broken binding wires is shown in Figure 15. The sample ruptured energetically with an engineering wall stress of 3,030 psi and a total free length elongation of 41.2 percent. The ruptured conduit separated into two pieces, connected by one strand of reinforcing wire.

Figure 15.
Sample 6AU12 After Tension Failure

Note: Hose markings in the photo are in error. Sample labeled 6UF12 was actually 6UA12.

Uniroyal Manuli sample 8UA10 was equipped with the Hydrasearch repair fitting, and it failed at the hose/nipple interface of the repair coupling. Both the outer polyester reinforcing plies and the inner liner failed simultaneously at end B with the conduit separating into two sections. Failure at the hose/nipple interface is common in hose tension tests due to the stress concentration effect caused by hose neck-down over the nipple. In some coupling designs, failure can also be induced at this location due to a pinching or cutting force at the hose/nipple interface. This is the probable reason for the lower value of maximum engineering wall stress carried by this sample than the other 8-inch ACP sample.

3.7 Kink Tests

Samples 8UA12A, 6UA30, 6UF20, and 8P12A and were subjected to kink tests over a range of internal pressures. All samples passed the kink test, none showing any permanent deformation or damage due to kinking. The table below summarizes the results of the tests. The radii reported in Table 6 are those immediately following the kink, it being impossible to anticipate the kink and measure the bending radius prior to kinking.

Table 6.
Kink Test Results

Minimum Radius After Kink
(inches)

Sample	0 psi	25 psi	50 psi	100 psi
8UA12A	32	11	13	--
6UA30	34	27	12	7
6UF20	76	12	11	2.5
8P12A	59	40	25.5	18

Attempts to determine minimum bend radius and kinking behavior using the logarithmic spiral kink apparatus as originally proposed were unsuccessful. When bending the hoses around the spiral, it was impossible to discriminate the onset of kinking due to the flattening of the hose at the contact line. It became obvious during the testing that further development work is required on the bending and kink test using the logarithmic spiral concept.

3.8 Torsional Stiffness Tests

Torsional stiffness tests were performed on samples 8P12A, 6UF20, 6UA12, and 8UA12A. Samples 8P12A, 6UA12, and 8UA12A were subjected to both a vertical torsion test in the SwRI Torsion Tower, and a horizontal torsion test in the SwRI Hose Horizontal Torsion Tank. Sample 6UF20, because of its length, was tested in the torsion tower only.

A set of torsional stiffness values for each sample were determined by plotting applied torque vs. angle of twist and evaluating the slope of the first portion of the curve (typically between zero and ten degrees of rotation depending upon the internal pressure). Beyond this first portion, the samples began to exhibit nonlinear behavior by buckling in one of two modes. The first buckling mode, observed at lower pressures and in shorter samples, is referred to as the "dogbone" mode. It is a localized buckling of the sample's cross section (see Figure 16). The second mode, observed primarily at higher pressures, is the corkscrew instability. In this mode the sample buckles out of plane forming a giant corkscrew shape as shown in Figure 17. For each test run, the sample was twisted until one of the modes of instability was induced. This technique insured that the linear behavior of the sample had been observed in its entirety. Figure 18 is a plot of applied torque vs. angle of twist for sample 8UA12A. Note the linear and nonlinear portions of the graph.

Figure 16.
The Dogbone Torsional Instability

Figure 17.
The Corkscrew Torsional Instability

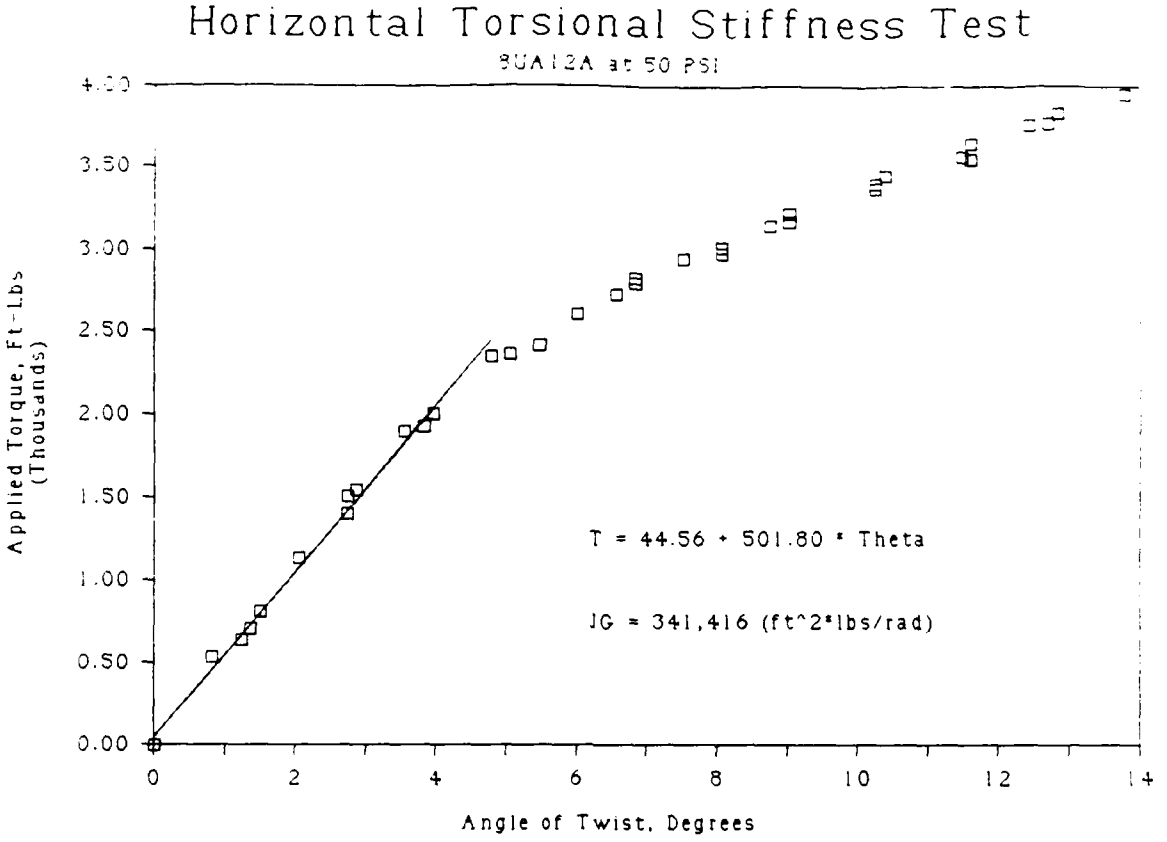


Figure 18.
Torque vs. Twist Plot for Sample 8UA12A

The hoses twisted in the vertical position were pressurized with water. For the horizontal tests, however, the hoses were pressurized with air in order to keep the test samples afloat during testing. Horizontal and vertical torsional stiffness values for each sample at each internal pressure are tabulated below and are presented graphically in Appendix B. Note that the stiffness values obtained in the horizontal tests were much higher than those of the vertical tests for all the samples. Larger frictional forces in the horizontal test apparatus can account for some of the discrepancy, but the magnitude of change is large enough to suggest a higher stiffness inherent to the horizontal position. This result is consistent with results of torsional stiffness tests conducted for the Navsea OPDS program, which also indicated a much higher value for torsional stiffness for hoses horizontal than for hoses which were vertical. This phenomena holds true even after the various frictional effects are accounted for.

No adequate explanation yet exists for this position dependent behavior. Because of the importance of the torsional stiffness on flowline hose performance, further research into this effect would certainly seem warranted.

Table 7.

Torsional Stiffness Test Results

Torsional Stiffness, JG

(ft^2-lb/rad)

Sample	0 psi	25 psi	50 psi	100 psi	150 psi	Orientation
8P12A	365,820	413,480	433,330	471,930	--	Horizontal
8UA12A	212,230	287,020	341,420	415,620	--	Horizontal
6UA12	126,560	163,790	201,920	227,070	--	Horizontal
8P12A	15,800	20,600	22,110	11,860	12,050	Vertical
6UA12	7,680	8,310	9,230	9,510	10,030	Vertical
8UA12A	7,220	19,330	21,690	25,440	26,350	Vertical
6UF20	2,590	2,810	1,820	1,260	1,610	Vertical

In general the torsional stiffness of the samples increased as internal pressure was increased. The only exceptions to this norm were samples 8P12B and 6UF20 in the vertical position. Sample 8P12A displayed increasing torsional stiffness as pressue was increased from 0 to 50 psi. At 100 psi, however, the stiffness dropped to approximately one half the 50 psi value. The stiffness then increased slightly at 150 psi.

One possible cause for this behavior is experimental error. With samples in the vertical position, it is very difficult to determine visually the onset of non-linear buckling behavior. For this reason, the torsional stiffness may have been evaluated over a range of twist values which were not as linear as had been assumed.

Another possible explanation is the nature of the Pirelli sample itself. Recall that this same construction also showed extremely low axial stiffness, with high elongations at only moderate loads. It is not unreasonable that a construction which manifests unusual behavior in one loading mode would also do the samein another. Since the construction details of the Pirelli design were not revealed to SwRI, it is not possible to speculate further regarding the behavior of the Pirelli samples.

Sample 6UF20 in the vertical position displayed a consistently low but decreasing JG value between 0 and 100 psi. At 150 psi the value increases slightly but is still lower than at 50 psi and below. Again, experimental error is suspected. Tne torsional stiffness for this sample is so low that "noise" in the testing method may have been a significant part of the measured results. The inherent seal friction in the hydraulic rotary actuator is probably of the same order of magnitude as the applied force to the hose sample, resulting in torque readings with a lot of data scatter.

Recall that sample 6UF20 was also the sample with the longitudinal reinforcement which led to low elongations under tension. Obviously, the trade-off for low elongation is low torsional stiffness in this design.

3.9 Crush Tests

Crush tests were performed on 48-inch sections of samples 8P12B, 6UF10B, 6UA12, and 8UA12A. Figure 19 shows the recovery behavior of each of the samples.

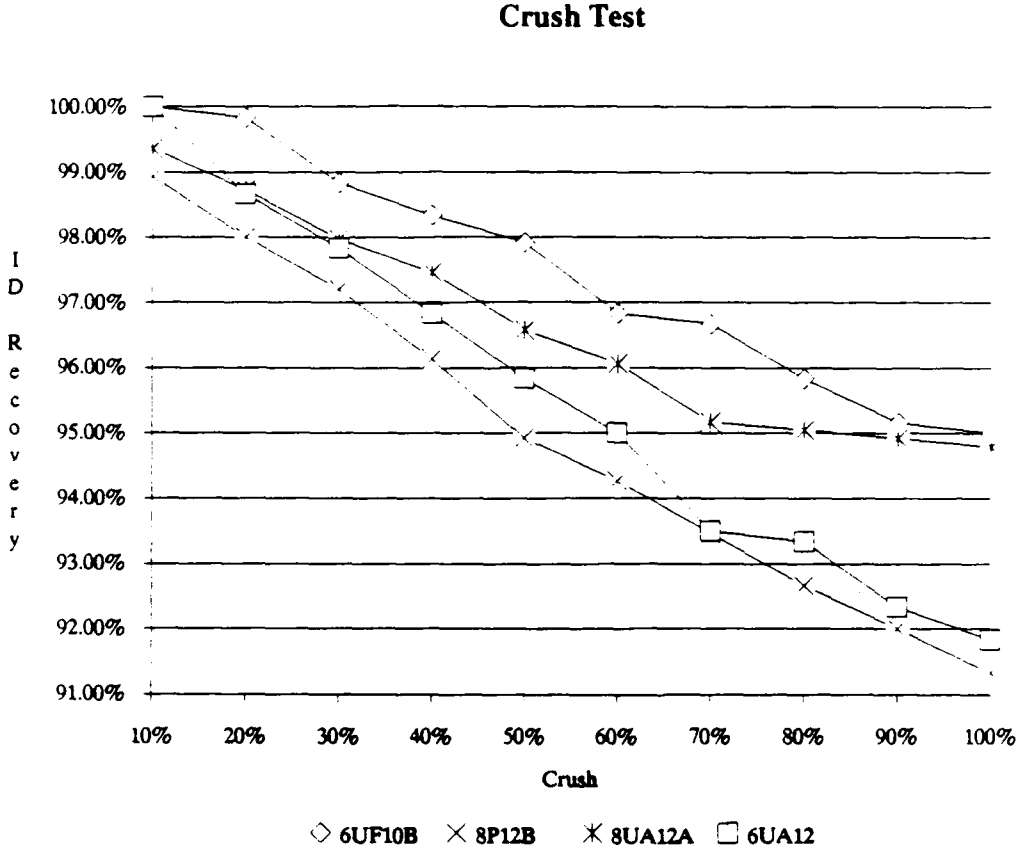


Figure 19.
Crush Recovery Performance

Each sample showed excellent crush recovery characteristics, and showed no signs of carcass damage even after 100 percent crush.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

4.1.1 Problem Areas

The testing program was reasonably successful, however all of the proposed objectives were not fully realized. A major complicating factor which was unforeseen at the time the project was planned was the effect of hose couplings on the results of the hydrostatic, burst, and axial tension tests. The hose/coupling interaction plays a critical role in the ultimate performance of a hose subjected to internal pressure or tension. The test program could have been improved by standardizing on at most two types of couplings; a built-in steel nipple and a standard clamp-on fitting. The Angus fitting was of such poor design that it had a pronounced effect on the test data for the Angus hoses in the three tests mentioned.

A further complicating factor was the two different sizes of hoses used for testing, both 6-inch and 8-inch diameters. There were insufficient samples of each size from each manufacturer to determine the effects, if any, of hose diameter on the testing results.

Yet another area for standardization should be hose length. More confidence could be placed in the results if comparisons could be made for hoses of the same length. A standard short length of hose; 12 feet; and a standard long length of hose; 20, 24, or 30 feet; would have made for more direct comparisons of results. As it was, the test program had hoses of 6, 10, 12, 20, and 30 feet. Standardized lengths also make test set-up much easier and lower testing program costs.

The logarithmic spiral apparatus originally planned for use in the kink test was a disappointment. The apparatus had been used successfully to determine the minimum bend radius for a flexible pipe, yet it did not function as planned with the hoses. The problem was the inherent compliance of the hoses, which permitted them to conform closely to the shape of the logarithmic spiral by flattening against it. As the hoses were bent to progressively smaller radii, no kinking behavior was observed because of the flattening.

The amount of torsional stiffness observed for hoses in the horizontal position in the Hose Horizontal Torsion Tank was totally unanticipated, and the apparatus was under-designed to withstand the loads which had to be imparted to the hose test samples in order to twist them. Eventually, good data was obtained after the apparatus was modified to resist warping, even though the fix was temporary.

4.1.2 Lessons From the Data

4.1.2.1 Acceptance Tests

A detailed internal inspection of the hose samples was not performed during the acceptance inspections based on the negative results of all such inspections on the recently completed OPDS

conduit test program. Had the inspection been performed, the hypothesized internal flaw which lead to the premature failure of Uniroyal Manuli sample 6UF10A in the kerosene test may have been discovered.

4.1.2.2 Hydrostatic Tests

The hydrostatic test results show that all hoses had primary reinforcement at the neutral reinforcement lay angle of 54.736 degrees, even though some samples had considerable longitudinal reinforcement also. The elongations during the hydrostatic test did not show any significant difference between hoses with and hoses without longitudinal reinforcement.

4.1.2.3 Kerosene and Vacuum Tests

The premature failure of sample 6UF10A highlights the importance of the kerosene test. The vacuum test is only useful for hoses of rigid cross section, however.

4.1.2.4 Burst Test

The burst test is a primary method of determining hose strength. The data would be more definitive if all hoses were terminated with couplings or fittings which were inherently stronger than the hose carcass. As it was, with some hoses failing in the carcass and others failing at the coupling, direct comparisons of carcass strength were not possible. The primary problem with clamp-on type couplings is their inability to resist the thrust loads generated by internal pressure acting on the blind flange face. The problem is one of inadequate gripping force on the hose wall at pressures approaching the ultimate strength of the carcass.

The hydrostatic test data do not correlate with the ultimate burst results. The performance during a simple hydrostatic test cannot be used to predict ultimate burst strength.

4.1.2.5 Axial Strength Tests

The axial stiffness tests were very revealing. The wide variance in performance in this test among the test samples is an indication of the importance of reinforcement type and lay angle. It is interesting to compare the Uniroyal Manuli 6-inch ACP and float/sink sample's performance with that of the Uniroyal Manuli OPDS conduit, as summarized in the table below.

Table 8.
Comparison of Uniroyal Manuli Test Results

Hose Type	Burst (psi)	Axial Stiffness (lbs/in)	Ultimate Axial Stress (psi)	Axial Strength (lbs)	Vertical Torsional Stiffness at 100 psi (ft^2-lb/rad)
Float/Sink	797	2,782	3,470	54,630	1,260
ACP	1,600	928	2,770	52,660	9,510
OPDS Conduit	3,385	408	5,260	96,145	1,985

From the table, the advantages of wire reinforcement in the OPDS conduit are obvious. Burst strength is more than twice that of the ACP construction with polyester reinforcement, and ultimate axial stress and strength are also much higher than in either the float/sink or ACP hoses. The real strength of the float/sink design is the longitudinal reinforcement, which gives remarkable improvement in elongation characteristics and axial stiffness. The ACP and float/sink constructions also showed much less tendency to neck-down under tension than did the OPDS conduit, which is a further benefit of the increased axial stiffness in both of these polyester reinforced hoses. The reduced neck-down is important so far as flow diameter is concerned, but also makes the ACP and float/sink hoses less prone to failure at the hose/coupling interface, since not as great a stress concentration is present.

4.1.2.6 Torsional Stiffness Tests

The continuing mystery remains the tremendous difference in performance in the torsional stiffness tests in the vertical and horizontal positions for all the hoses tested. Some fundamental principal is at work here which has not yet been adequately explained. Until such time, it is prudent to test the torsional stiffness of a hose in the position in which it is most likely to be used. Lack of understanding of the reasons for the difference in performance between the vertical and horizontal does not mean that the experimental results cannot be used to good advantage in design calculations.

4.1.2.7 Kink Test

The kink test data is qualitative. The test is useful for determining the toughness of hoses, but the method is not precise enough to generate quantitative information useful from a systems design point of view.

4.1.2.8 Crush Test

The crush test, like the kink test, is best used to test the toughness of the hose and its ability to withstand abuse. The results are not useful to generate quantitative data.

4.2 Recommendations

Upon reviewing the test program and the results generated, several recommendations can be made regarding the testing methods and future hose research.

Uniform samples for testing should be a goal. To the greatest extent possible, test samples should be of the same length, diameter, and termination type in order to make accurate data comparisons and determine trends.

Better coupling systems need to be developed which can resist the thrust loads at burst pressures. The Angus coupling, in particular, performs very poorly.

The kink test apparatus needs improvement. The OCIMF bending stiffness and kink test is inadequate to generate good quality quantitative results, and the logarithmic spiral apparatus needs further development.

The kerosene and vacuum tests are very useful for rigid cross section hoses, but a satisfactory alternative needs to be developed for lay flat type hoses. It is easy enough to pressurize a lay flat type hose with kerosene, but putting a vacuum on the hose only flattens it, making it impossible to detect any bleed-back by kerosene which may have penetrated the carcass.

Much work remains to be done with the torsional stiffness tests. The next step should be to develop a much larger horizontal test tank, so that longer lengths can be twisted while floating. This would permit more direct comparisons between tests in the vertical position and those in the horizontal position. Further, thought should be given to fabricating a device to twist the hoses at any angle of elevation between horizontal and vertical. The results of such a test would greatly aid in understanding the physical mechanism causing the differences in torsional stiffness. More analytical work is also required to study the possible reasons for changes in torsional stiffness depending on position.

Finally, until such time as the results can be made quantitative, kink and crush tests could be eliminated as test methods in future programs. The data from these tests is too qualitative to be useful for comparing hose constructions.

APPENDIX A

ABBREVIATED TEST PROCEDURES

Hydrostatic and Burst Test

1. Lay sample out straight with both flanged ends on roller dollies.
2. Use visipak/strip chart to record test pressures.
3. Pressurize the sample cyclically 15 times to the designated hydrostatic test pressure. During this time verify the proper operation of all instruments.
4. Pressurize the sample to 10 PSI and record the flange to flange length.
5. Increase the pressure over a period of 5 minutes to 1/2 the test pressure, hold for 10 minutes, then reduce to zero.
6. Increase the pressure over a period of 5 minutes to the test pressure and hold for 10 minutes.
7. Inspect the sample for leaks and record the flange to flange length.
8. Reduce the pressure to 0 over a period of 5 minutes.
9. After 15 minutes, repressurize the sample to 10 PSI and record the flange to flange length.
10. Slowly pressurize the sample to the minimum acceptable burst pressure over a period of 15 minutes and hold for 15 minutes.
11. Slowly increase the pressure until the sample bursts.

Angus Hydrostatic and Burst Test

1. Use visipak/strip chart to record test pressures.
2. Hang sample from the lift in the Hi-Cap machine. Attach the 650 lb weight to the lower flange and lift the hose/weight so that the maximum length of hose is visible from the instrument table.
3. Measure the flange to flange length at 0 psi.
4. Pressurize the sample cyclically 3 times between 50 PSI and the designated hydrostatic test pressure. During this time verify the proper operation of all instruments.
5. At 50 PSI record the flange to flange length.
6. Increase the pressure over a period of 3 minutes to 1/2 the test pressure, hold for 5 minutes, then reduce to 50 PSI.
7. Increase the pressure over a period of 3 minutes to the test pressure and hold for 5 minutes.
8. Inspect the sample for leaks and record the flange to flange length.
9. Reduce the pressure to 50 PSI then record the flange to flange length.
10. Slowly pressurize the sample to the minimum acceptable burst pressure over a period of 5 minutes.
11. Slowly increase the pressure until the sample bursts.

Kerosene Test

1. Lay the sample out straight with each end resting on a dolly (additional dollies should be used to support the middle of longer hoses).
2. Blank off the ends with ANSI class 300 blind flanges and fill the sample with kerosene.
3. Use a visipak and strip chart recorder to display/record the test pressures.
4. Pressurize the sample to its maximum operating pressure and hold for 6 hours.
5. During this time observe the hose for signs of leaking, swelling, blistering, or other failure.
6. After 6 hours, reduce the pressure to 1/2 the operating pressure and hold for 12 hours.
7. After 12 hours drain and vent the sample.
8. Remove the blind flanges and dry the bore with rags.
9. Using a strong light, inspect the bore for signs of blistering or delamination.

Vacuum Test

1. Perform this test immediately following the Kerosene test. Samples should be layed out straight and supported by dollies.
2. Ensure that the sample bore has been dried thoroughly.
3. Using hi-vacuum grease, blank off both ends of the sample with clear acrylic flanges.
4. Apply 15" (Hg) vacuum to the sample and hold for 10 minutes.
5. Using a strong light, inspect the sample for Kerosene weeping back into the bore (pay special attention to the built in nipple areas), blistering, delamination, or collapse of the inner tube.

Axial Load vs. Deformation and Axial Stength Test

1. Install the hose sample in the tensile test machine.
2. Verify the initial measurements taken during the acceptance test.
   (a) Measure length along the single, axial stripe.
   (b) Measure the outside diameter using a Pi tape. Take measurements at each circumferential band.
3. Load the sample in 5,000lb increments. At each increment, allow the hose to elongate at constant load for 5 minutes, then repeat measurements 2(a) and (b). Continue loading and taking measurements up to the pre-determined test tension.
4. At the test tension, hold the load constant for 15 minutes. Repeat measurements 2(a) and (b).
5. Unload the sample to zero tension and allow to relax for 1 hour. Repeat measurements 2(a) and (b).
6. Video tape the remainder of the test.
7. Use a string potentiometer to measure elongation during this phase.
8. Load the sample *smoothly and continuously until failure* occurs.

Kink Test

1. Lay sample out straight on roller dollies. Install a blind flange and lever arm on each end (one flange should be plumbed to allow pressurization).
2. Attach a dynamometer to one lever arm. Attach a cable puller between the dynamometer and the other lever arm.
3. Begin at 0 PSI internal pressure with the dynamometer zeroed.
4. Draw the ends of the sample together with the cable puller until a kink forms. Make note of the dynamometer reading just prior to kinking.
5. Using a tape measure, determine the minimum radius of the sample at the kink. Photograph the kinked sample.
6. Unkink the sample and allow it to relax while pressurizing to the next internal pressure.
7. Repeat steps 4 through 6 for internal pressures of 25, 50, and 100 PSI.

Vertical Torsional Stiffness Test

1. Install the sample in the Torsion Tower and plumb for pressurization at the lower end. Fill the sample with water.
2. Use visipak/strip chart to record the hydraulic pressures delivered to the rotary table.
3. Begin with 0 PSI internal pressure.
4. Twist the sample until buckling is observed. Repeat 3 times noting the approximate amount of twist required to buckle the sample.
5. Divide the value determined in step 3 into 10 to 15 equal increments (normally 3 to 5 degrees per increment).
6. Allow the hose to relax and record the "zero" position of the twist indicator.
7. Apply twist to the sample slowly and smoothly. Record the hydraulic pressure at each pre-determined increment (i.e. 0, 3, 6, 9...).
8. Continue to apply twist until buckling is observed, then take 1 additional reading.
9. Repeat steps 6 through 8 twice, making a total of 3 runs at each internal pressure.
10. Allow the sample to relax while pressurizing to the next internal pressure.
11. Repeat steps 4 through 10 for internal pressures of 25, 50, 100, and 150 PSI.

Horizontal Torsional Stiffness Test

Equipment

The samples were tested in the SwRI Horizontal Torsional Test Machine. The test machine consists of a frame and water tank assembly in which the hose sample is floated in the tank and attached at either end to the frame. At one end, the sample is bolted to a blind flange which is welded to the test frame. At the other end the sample is fitted with a special flange to which a central post is attached. The central post slides into the test frame and is free to rotate and slip axially. This arrangement constrains the lateral movement of the hose as t applied.
Torque is applied to the sample via a moment arm attached to the flange at the live end of the hose. The end of the moment arm is a curved shoe with the radius of curvature equal to the moment arm length. The torque arm is actuated by means of a cable which wraps around the periphery of the curved shoe, insuring constant moment arm length over a 30 degree angle of rotation. The cable tension required to rotate the sample is provided by a come-a-long and measured with an in line dynamometer. The cable tension, multiplied by the moment arm length, yields the applied torque. The dead end flange is equipped with fittings to allow air pressurization of the sample to pre- determined internal pressure levels.

Procedure

After mounting the sample in the test machine, the water level was raised until it covered the sample. The sample was then taken through a testing sequence consisting of twisting the sample to various angular displacements and measuring the applied torque, all over a range of internal pressures. In each instance, the twisting was stopped when the sample began to show evidence of cross sectional buckling.

Crush Test

Equipment

The crush test samples were tested in SwRI's Tinius Olsen tensile testing machine. For this test a 6.25" long by 9.69" diameter section of pipe is attached to the cross head and used as a crushing ram. A deflectometer is used to measure the cross head travel as each sample is crushed. The cross head travel provides a measurement of both the amount of crush applied, and the deformation remaining after the crushing force is removed.

Procedure

Each sample was loaded into the test machine so that the crushing load would be applied with the axis of the sample parallel to the axis of the ram (simulating a vehicle driving over the hose). The cross head was zeroed with the crushing ram just touching the sample. The sample was then crushed to predetermined percentages of its original cross section in 10% increments (90%, 80%, 70%,...0%). The sample was allowed to relax for 1 minute between steps. During the test the applied load vs. cross head travel was recorded by an x-y plotter so the force required for each amount of crush could be determined as well as the residual deformation after each 1 minute hold. After the last increment was completed, the hose was allowed to relax for 5 minutes and the residual deformation again measured.

APPENDIX B

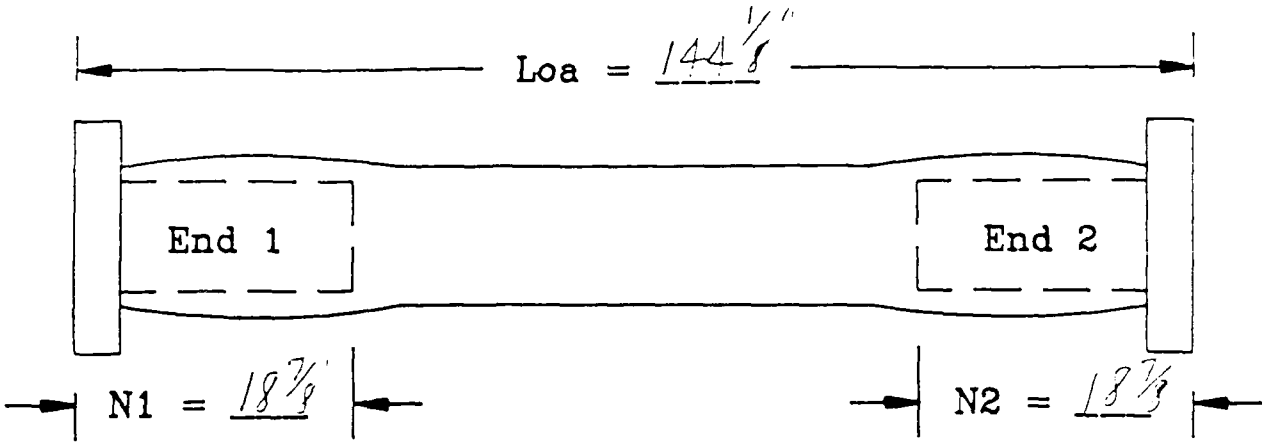
RAW TEST DATA

Data Package for Pirelli Sample 8P12A

Acceptance Test Data Sheet

Data Sheet No. 006

Hose I.D. Code 8-24



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	10.984"
48.0"	10.300"
72.0"	10.175"
96.0"	10.156"
120.0"	11.165"

Signature	Date
[signature]	[illegible]

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
6UA30 ~~6UF30~~	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
6UA30 ~~6UF30~~	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
6UA30 ~~6UF30~~	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

8P12A

Kink Test

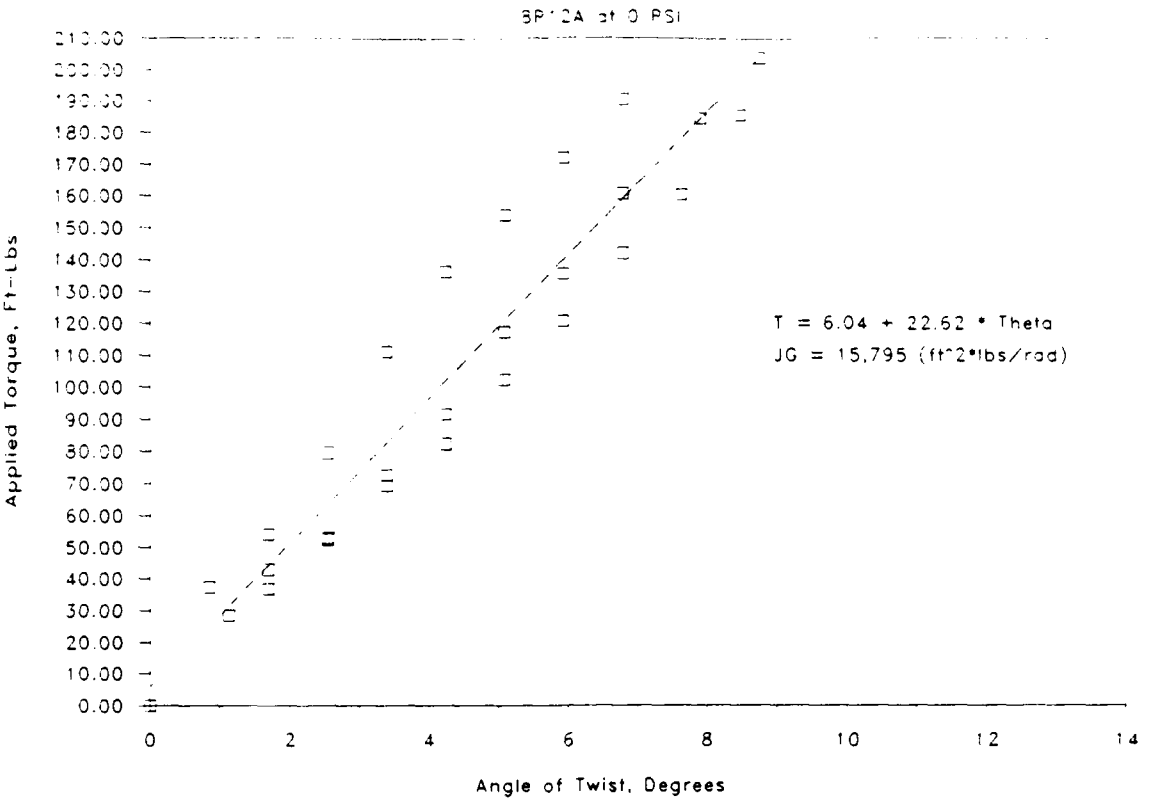
Intrnl Press (psi)	X (in)	Y (in)	R (in)	Req'd Pull (lbs)
0	120.50	26.25	59.00	250
25	105.00	36.50	40.00	300
50	91.50	42.00	25.50	350
100	61.75	49.25	18.00	540

Torsional Stiffness Test 8P12A

) PSI Internal Pressure - RAW DATA:

Rotation (MM)	Rotation (Deg)	Run 1 Hyd Press (PSI)	Run 1 Torque (Ft-Lb)	Run 2 Hyd Press (PSI)	Run 2 Torque (Ft-Lb)	Run 3 Hyd Press (PSI)	Run 3 Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846			154	37.3		
4	1.129					118	28.6
6	1.693	223	54.1	177	42.9	152	36.8
9	2.539	328	79.5	216	52.4	218	52.8
12	3.386	458	111.0	286	69.3	300	72.7
15	4.232	561	136.0	339	82.2	377	91.4
18	5.078	635	154.0	422	102.3	483	117.1
21	5.925	709	171.9	497	120.5	558	135.3
24	6.771	786	190.6	586	142.1	663	160.8
27	7.618			662	160.5		
28	7.900					762	184.8
30	8.464			766	185.7		
31	8.746					841	203.9

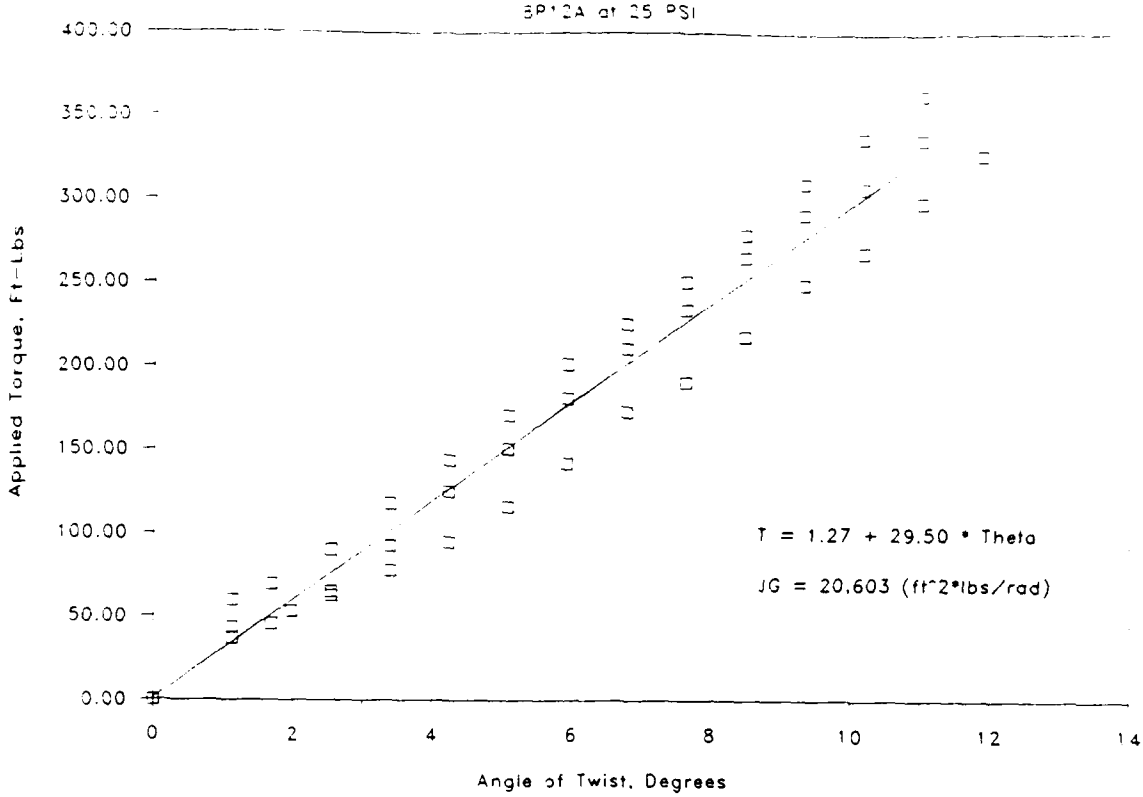
Torsional Stiffness Test



25 PSI Internal Pressure - RAW DATA 8P12A

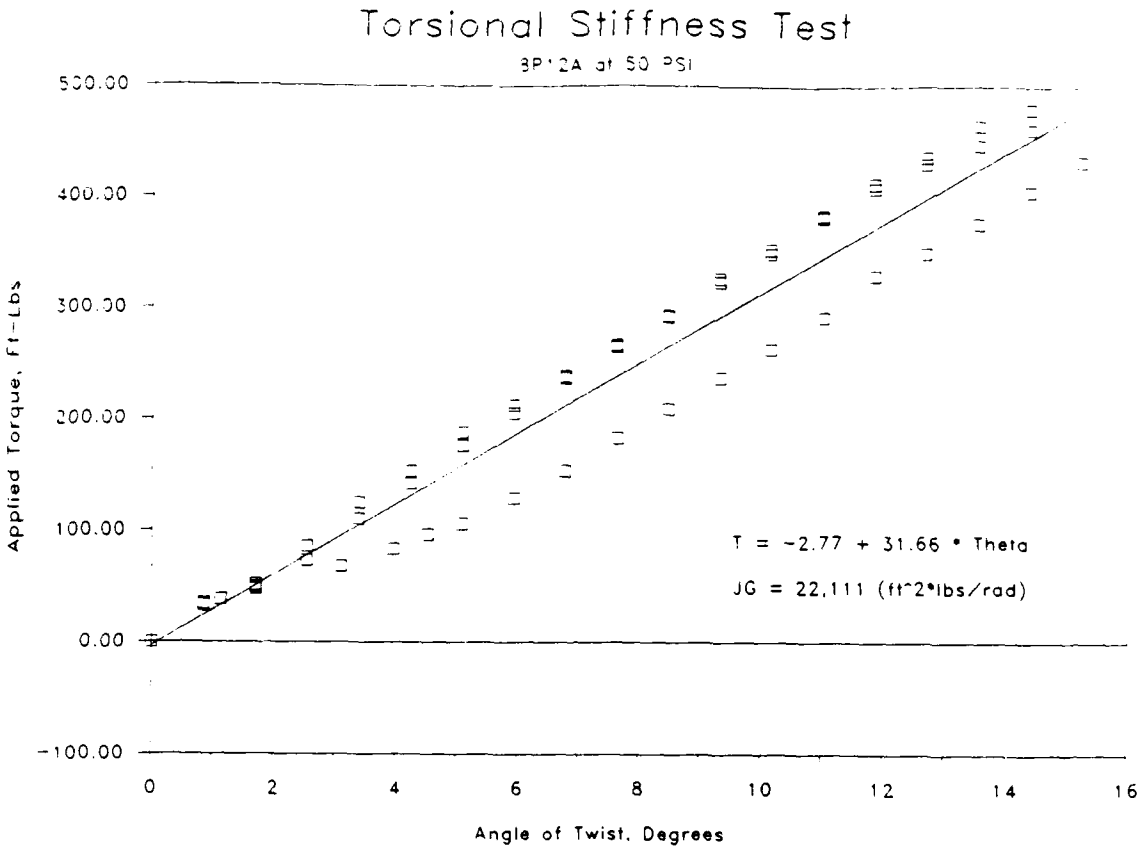
		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
4	1.129	153	37.1	247	59.9	180	43.6
6	1.693	188	45.6	286	69.3		
7	1.975					220	53.3
9	2.539	268	65.0	371	89.9	258	62.5
12	3.386	381	92.4	485	117.6	320	77.6
15	4.232	514	124.6	592	143.5	389	94.3
18	5.078	619	150.1	702	170.2	476	115.4
21	5.925	742	179.9	827	200.5	583	141.4
24	6.771	866	210.0	927	224.8	711	172.4
27	7.618	962	233.3	1031	250.0	783	189.9
30	8.464	1091	264.5	1147	278.1	896	217.3
33	9.310	1197	290.2	1275	309.2	1024	248.3
36	10.157	1263	306.3	1389	336.8	1104	267.7
39	11.003	1385	335.8	1496	362.8	1227	297.5
42	11.850					1347	326.6

Torsional Stiffness Test



50 PSI Internal Pressure - RAW DATA 8P12A

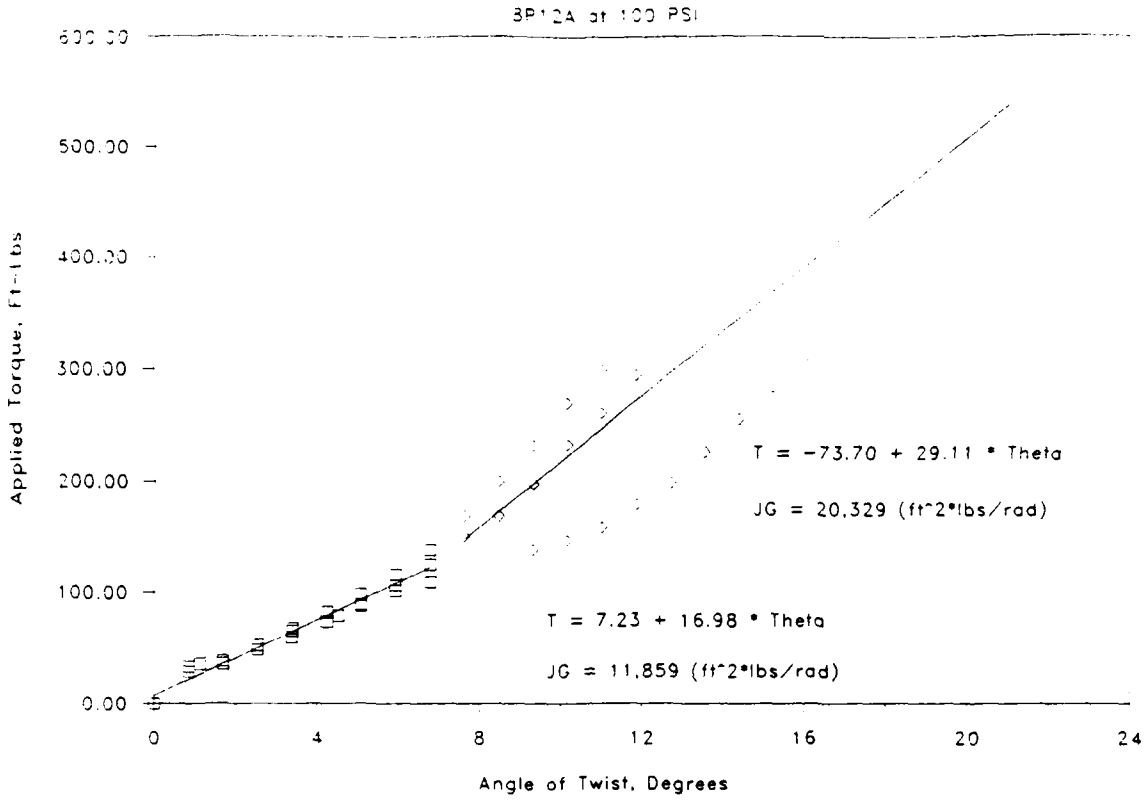
Rotation (MM)	Rotation (Deg)	Run 1 Hyd Press (PSI)	Run 1 Torque (Ft-Lb)	Run 2 Hyd Press (PSI)	Run 2 Torque (Ft-Lb)	Run 3 Hyd Press (PSI)	Run 3 Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846	144	34.9			137	33.2
4	1.129			157	38.0		
6	1.693	203	49.2	196	47.5	212	51.4
9	2.539	300	72.7			352	85.3
11	3.103			278	67.4		
12	3.386	455	110.3			513	124.4
14	3.950			343	83.2		
15	4.232	586	142.1			630	152.7
16	4.514			397	96.2		
18	5.078	723	175.3	435	105.5	772	187.2
21	5.925	843	204.4	530	128.5	872	211.4
24	6.771	973	235.9	631	153.0	981	237.9
27	7.618	1092	264.8	753	182.6	1098	266.2
30	8.464	1210	293.4	861	208.8	1206	292.4
33	9.310	1337	324.2	977	236.9	1350	327.3
36	10.157	1457	353.3	1082	262.4	1444	350.1
39	11.003	1582	383.6	1202	291.5	1576	382.2
42	11.850	1683	408.1	1358	329.3	1699	412.0
45	12.696	1773	429.9	1445	350.4	1799	436.2
48	13.542	1844	447.1	1558	377.8	1918	465.1
51	14.389	1905	461.9	1675	406.2	1982	480.6
54	15.235			1786	433.1		


Torsional Stiffness Test
8P12A at 50 PSI
500.00
400.00
300.00
200.00
100.00
0.00
-100.00
Applied Torque, Ft-Lbs
0
2
4
6
8
10
12
14
16
Angle of Twist, Degrees
T = -2.77 + 31.66 * Theta
JG = 22,111 (ft^2*lbs/rad)

100 PSI Internal Pressure - RAW DATA 8P12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846			138	33.4	119	28.8
4	1.129	148	35.9				
6	1.693			159	38.5	147	35.6
9	2.539	201	48.7	219	53.1	201	48.7
12	3.386	248	60.1	280	67.9	270	65.5
15	4.232	304	73.7			339	82.2
16	4.514			326	79.0		
18	5.078	368	89.2	364	88.2	403	97.7
21	5.925	438	106.2	418	101.3	477	115.6
24	6.771	514	124.6	450	109.1	569	138.0
27	7.618	618	149.8			697	169.0
30	8.464	695	168.5	509	123.4	822	199.3
33	9.310	812	196.9	568	137.7	953	231.1
36	10.157	956	231.8	604	146.4	1108	268.7
39	11.003	1072	259.9	652	158.1	1230	298.2
42	11.850	1211	293.6	735	178.2	1344	325.9
45	12.696	1316	319.1	815	197.6	1483	359.6
48	13.542	1446	350.6	930	225.5	1604	388.9
51	14.389			1051	254.8	1722	417.6
52	14.671	1608	389.9				
54	15.235	1696	411.3	1169	283.5	1836	445.2
57	16.082	1792	434.5	1287	312.1	1921	465.8
60	16.928			1405	340.7		
61	17.210	1944	471.4			2082	504.9
63	17.774	1999	484.7			2159	523.5
64	18.056			1558	377.8		
66	18.621	2088	506.3	1623	393.6	2254	546.6
69	19.467			1725	418.3	2339	567.2
72	20.313	2222	538.8	1848	448.1	2471	599.2
76	21.442			1972	478.2		
78	22.006			2024	490.8		

Torsional Stiffness Test



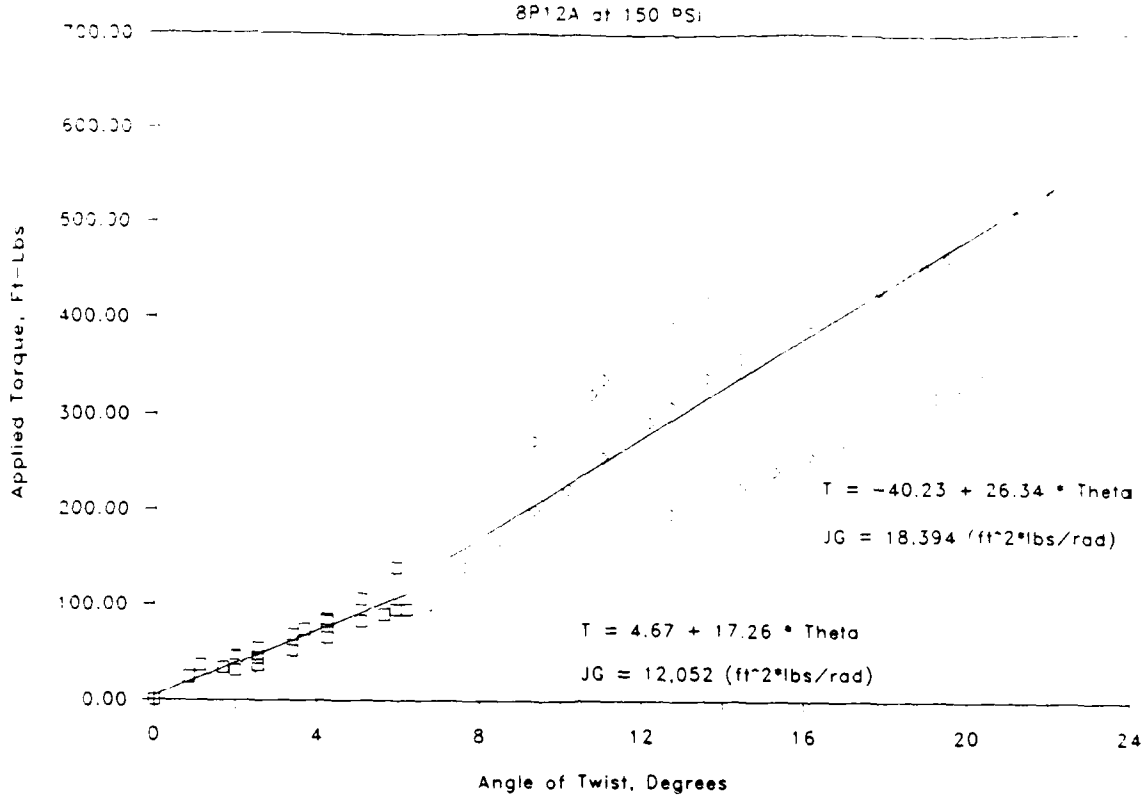
150 PSI Internal Pressure - RAW DATA

8P12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846					100	24.2
4	1.129			151	36.6		
6	1.693	141	34.2				
7	1.975			198	48.0	129	31.3
9	2.539	187	45.3	231	56.0	156	37.8
12	3.386			286	69.3	215	52.1
13	3.668	308	74.7				
15	4.232	352	85.3	342	82.9	272	65.9
18	5.078	442	107.2			345	83.6
20	5.643			371	89.9		
21	5.925	575	139.4			393	95.3
22	6.207			391	94.8		
24	6.771	701	170.0	412	99.9	477	115.6
27	7.618	827	200.5	488	118.3	578	140.1
30	8.464	966	234.2	563	136.5	693	168.0
33	9.310	1124	272.5			623	199.6
34	9.592			627	152.0		
36	10.157			641	155.4	914	221.6
38	10.721	1322	320.6				
39	11.003	1388	336.6	692	167.8	1054	255.6
42	11.850	1521	368.8	742	179.9		
43	12.132					1201	291.2
45	12.696	1652	400.6	806	195.4	1270	307.9
48	13.542	1761	427.0	867	210.2	1393	337.8
51	14.389	1876	454.9	918	222.6	1478	358.4
54	15.235	1995	483.8	994	241.0		
57	16.082	2115	512.9	1064	258.0	1637	396.9
60	16.928	2225	539.5	1127	273.3	1723	417.8
63	17.774	2332	565.5	1221	296.1	1778	431.1
67	18.903					1878	455.4
68	19.185	2439	591.4	1313	318.4		
69	19.467	2507	607.9			1922	466.1
70	19.749			1365	331.0		
72	20.313	2618	634.8	1391	337.3	1997	484.2
75	21.160	2706	656.2	1451	351.8	2104	510.2
78	22.006					2197	532.7
81	22.853					2355	571.1
84	23.699					2503	606.9

Torsional Stiffness Test

8P12A at 150 PSI

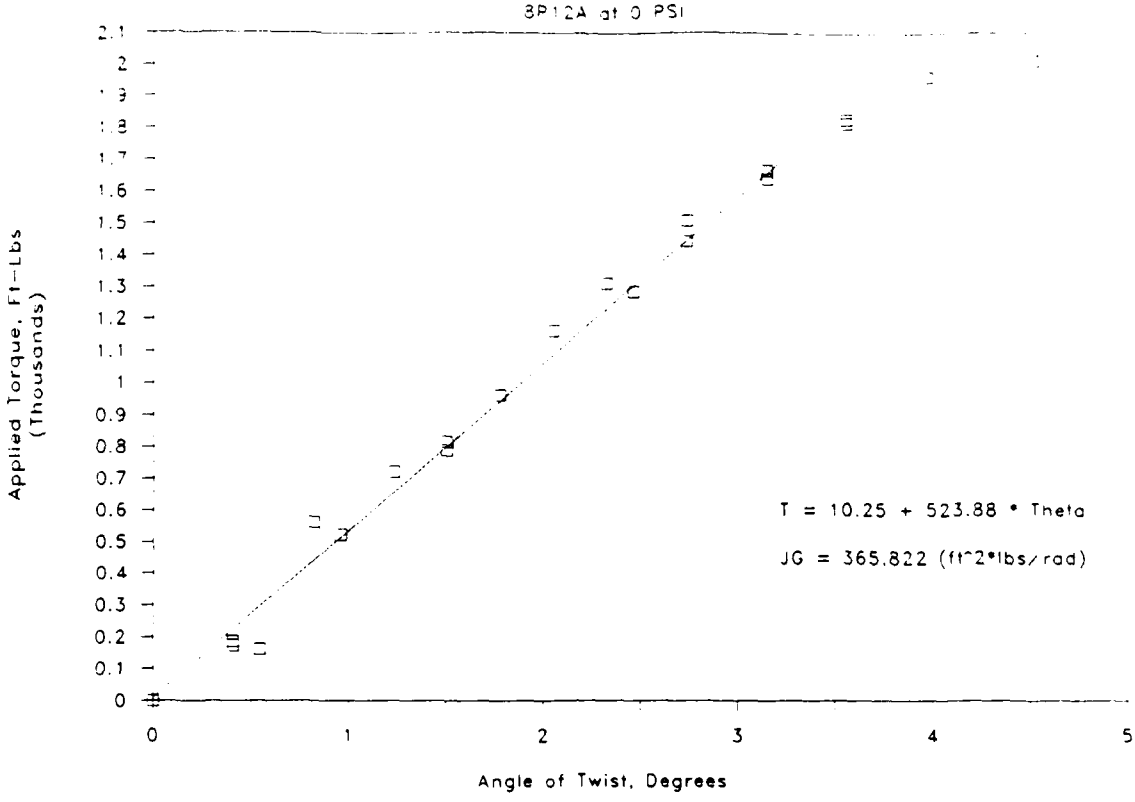


Horizontal Torsional Stiffness Test 8P12A

0 PSI Internal Pressure - RAW DATA:

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
3	0.410	140	186.7			130	173.3
4	0.547			120	160.0		
6	0.820	420	560.0				
7	0.957			390	520.0	390	520.0
9	1.230	540	720.0				
11	1.504			590	786.7	610	813.3
13	1.777	720	960.0				
15	2.051					870	1160.0
17	2.324			980	1306.7		
18	2.461	960	1280.0				
20	2.734			1080	1440.0	1130	1506.7
23	3.144	1250	1666.7	1230	1640.0	1250	1666.7
26	3.554	1360	1813.3	1360	1813.3	1370	1826.7
29	3.965			1470	1960.0	1470	1960.0
31	4.238	1430	1906.7				
33	4.511			1520	2026.7	1510	2013.3

Horizontal Torsional Stiffness Test

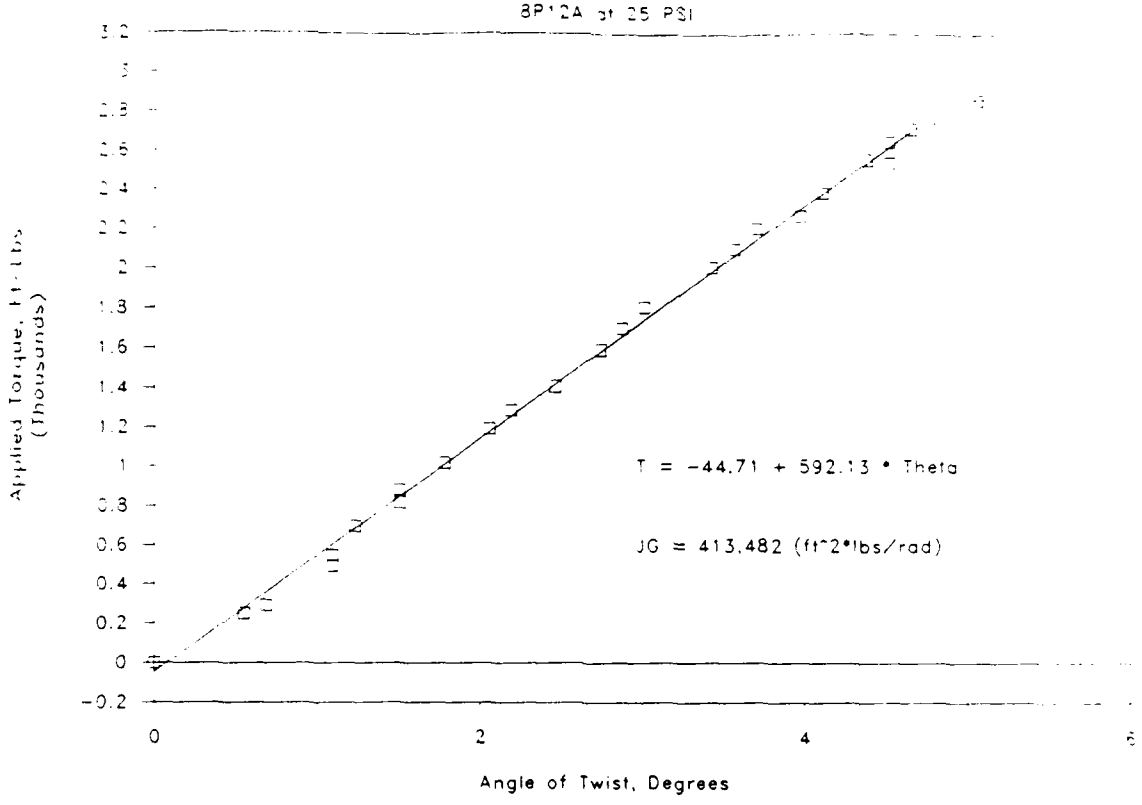


25 PSI Internal Pressure - RAW DATA: 8P12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
4	0.547	190	253.3	190	253.3		
5	0.684					220	293.3
8	1.094			370	493.3	410	546.7
9	1.230	520	693.3				
11	1.504			610	813.3	660	880.0
13	1.777	760	1013.3				
15	2.051			890	1186.7		
16	2.187					960	1280.0
18	2.461	1050	1400.0				
20	2.734			1190	1586.7		
21	2.871					1270	1693.3
22	3.008	1350	1800.0				
25	3.418			1500	2000.0		
26	3.554					1570	2093.3
27	3.691	1650	2200.0				
29	3.965					1700	2266.7
30	4.101			1790	2386.7		
32	4.375	1920	2560.0				
33	4.511			1910	2546.7	1990	2653.3
34	4.648	2040	2720.0				
35	4.785			2040	2720.0		
36	4.922					2100	2800.0
37	5.058	2130	2840.0	2150	2866.7		
41	5.605					2310	3080.0
43	5.879	2320	3093.3	2340	3120.0		
46	6.289					2320	3093.3

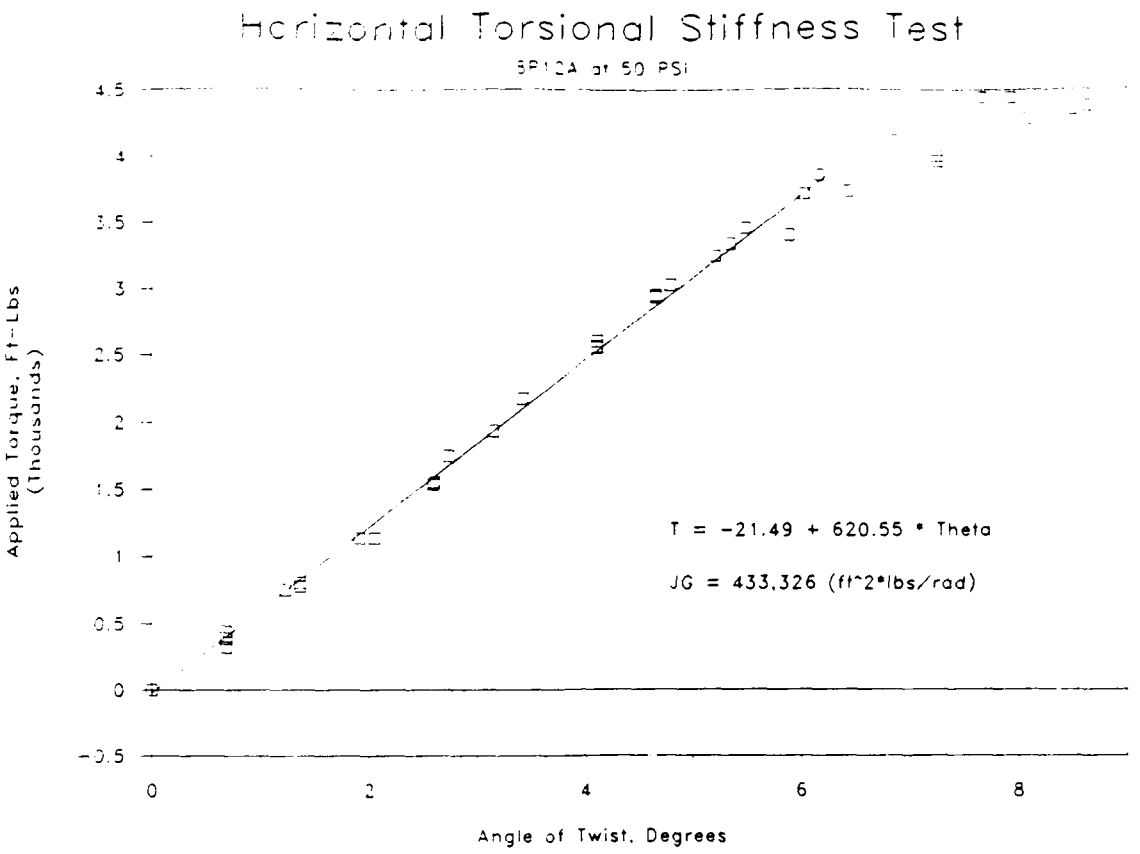
Horizontal Torsional Stiffness Test

8P12A at 25 PSI



50 PSI Internal Pressure - RAW DATA: 8P12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
5	0.684	240	320.0	290	386.7	330	440.0
9	1.230					560	746.7
10	1.367	580	773.3	600	800.0		
14	1.914	850	1133.3			850	1133.3
15	2.051			850	1133.3		
19	2.598	1150	1533.3	1160	1546.7		
20	2.734					1310	1746.7
23	3.144			1450	1933.3		
25	3.418	1630	2173.3			1630	2173.3
30	4.101	1920	2560.0	1915	2553.3	1950	2600.0
34	4.648	2210	2946.7	2200	2933.3		
35	4.785					2270	3026.7
38	5.195	2430	3240.0				
39	5.332			2500	3333.3		
40	5.468					2590	3453.3
43	5.879	2550	3400.0				
44	6.015			2780	3706.7		
45	6.152					2890	3853.3
47	6.425	2800	3733.3				
49	6.699			2990	3986.7		
50	6.836	2910	3880.0			3150	4200.0
53	7.246	2970	3960.0	3000	4000.0		
56	7.656					3330	4440.0
58	7.929	3330	4440.0				
59	8.066			3210	4280.0		
62	8.476			3260	4346.7		
63	8.613					3280	4373.3

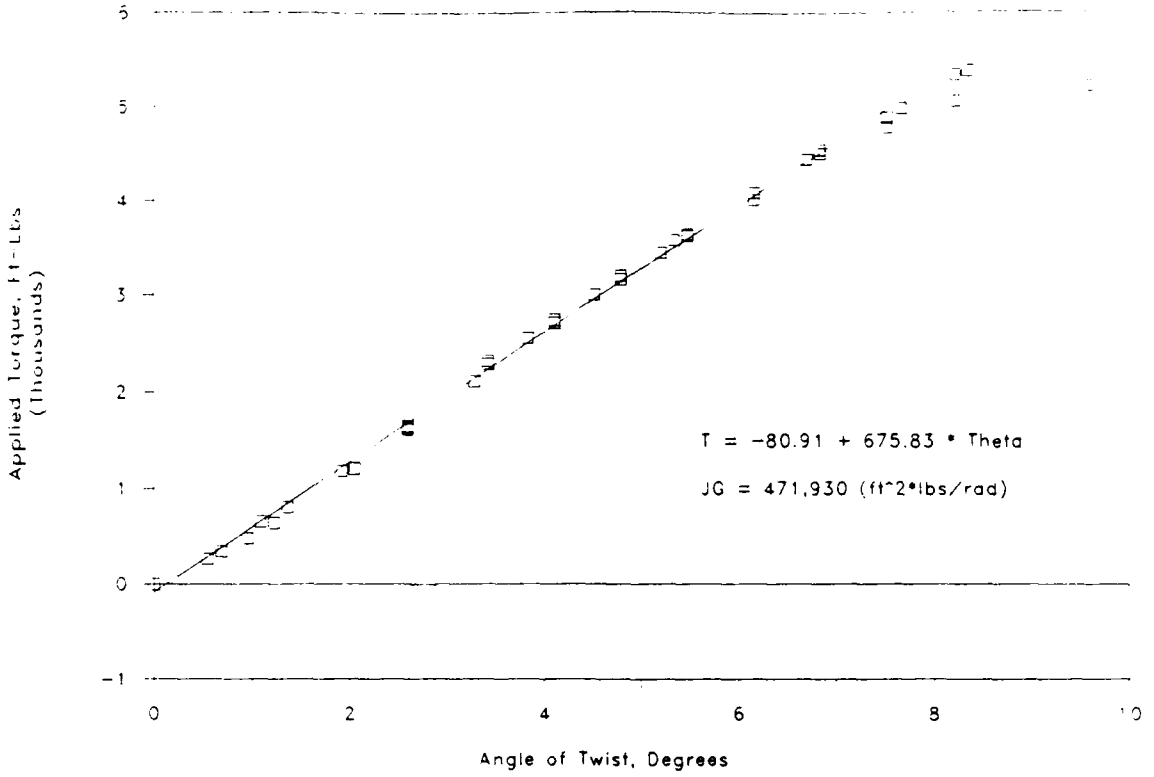

Horizontal Torsional Stiffness Test
3P12A at 50 PSI
Applied Torque, Ft-Lbs (Thousands)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
0
2
4
6
8
Angle of Twist, Degrees
T = -21.49 + 620.55 * Theta
JG = 433,326 (ft^2*lbs/rad)

100 PSI Internal Pressure - RAW DATA: 8P12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
4	0.547					200	266.7
5	0.684	260	346.7				
7	0.957			360	480.0		
8	1.094	490	653.3				
9	1.230					480	640.0
10	1.367			600	800.0		
14	1.914	880	1173.3	880	1173.3		
15	2.051					900	1200.0
19	2.598	1220	1626.7	1205	1606.7	1230	1640.0
24	3.281	1580	2106.7				
25	3.418			1715	2286.7	1740	2320.0
28	3.828	1920	2560.0				
30	4.101			2040	2720.0	2060	2746.7
33	4.511	2260	3013.3				
35	4.785			2380	3173.3	2410	3213.3
38	5.195	2600	3466.7				
39	5.332			2700	3600.0		
40	5.468	2750	3666.7			2740	3653.3
45	6.152	3090	4120.0	3030	4040.0	3090	4120.0
49	6.699			3350	4466.7		
50	6.836	3400	4533.3			3430	4573.3
55	7.519	3600	4800.0	3680	4906.7		
56	7.656					3750	5000.0
60	8.203	3810	5080.0	4020	5360.0		
61	8.339					4050	5400.0
70	9.570	3940	5253.3				

Horizontal Torsional Stiffness Test

3P12A at 100 PSI

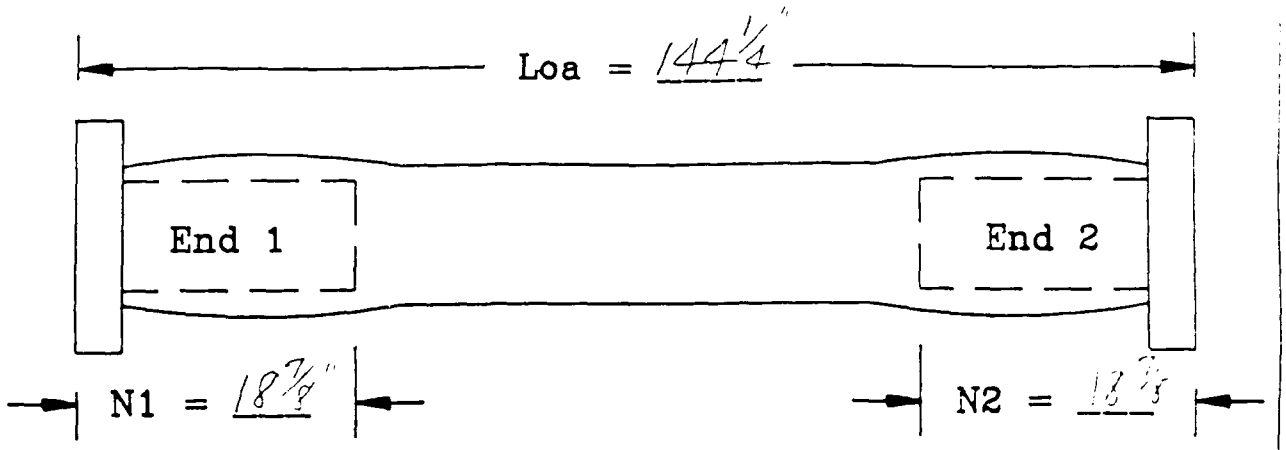


Data Package for Pirelli Sample 8P12B

Acceptance Test Data Sheet

Data Sheet No. 007

Hose I.D. Code



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	11.000"
48.0"	10.284"
72.0"	10.432"
96.0"	10.239"
120.0"	11.086"

Signature: Joe P. [illegible]

Date: [illegible]

SOUTHWEST RESEARCH INSTITUTE

San Antonio, Texas 78284

KEROSENE TEST — HI – 8UA12B & ~~6UF30~~ 6UP30

LOW – 8P12B & 6UF10A

TIME	HI	LOW	
2230	1066	610	
2245	1065	604	
23:00	1061	599	6UF10A Blew Apart At End B
23:17	1070	683	8P12B WASN't ~~open~~ pressurized @ 1st HR-
23:30	1058	630	" over pressurized, just letting pist settle
2345	1065	602	
2400	1064	599	
~~00~~15	1061	595	
~~00~~30	1058	594	
~~00~~45	1061	631	
100	1052	614	
1:15	1061	601	
1:30	1068	608	
1:45	1061	598	
2:00	1066	607	
2:15	1060	597	
2:30	1071	607	
2:45	1066	598	
300	1062	592	
3:15	1064	609	
3:30	1057	601	
3:45	1065	604	
4:00	1061	597	
4:15	1070	605	
4:30	534	598	
04:45	537	607	
05.00	537	601	
0515	536	609	
0530	535	604	(304) pressure reduced in 8P12B to 30 p
0545	533	307	
0600	531	309	
0615	530	304	
0630	534	304	
0645	533	304	
0700	532	303	

Date: 10/27/88

Signature: Dale Johnson / Joe Conaway

(SwR 171) Rev 6/75

KEROSENE TEST

TIME	HI	LOW	
0715	531	302	
0730	529	301	
0745	535	300	
0800	532	303	
0815	529	302	
0835	538	301	
0900	539	302	
0915	540	302	
0930	541	302	
1000	535	307	
1015	538	309	
1030	541	312	- BLED BOTH DOWN
1045	532	305	
1100	537	309	
11.15	544	315	- Bled Both Down
11:16	531	302	
11:30	537	309	
11:45	543	314	- Bled Both Down
11:46	529	302	
12:02	536	312	
1212	529	302	Bled Both Down
12:30	543	316	Bled Both Down
12:31	529	299	
12:55	556	329	Bled Both Down
12:57	528	300	
13:15	542	322	Bled off Both.
13:16	529	302	
1337	550	343	Bled both
1338	529	303	
1400	550	327	Bled both
14:1	528	302	
1420	550	327	
1430	533	306	
1440	504	316	
1500	470	312	End Test

Date: 10/28/98

Signature: D. W. Johnson

(SwRI 17) Rev 6, 1/5

SOUTHWEST RESEARCH INSTITUTE
DEPARTMENT OF STRUCTURAL AND MECHANICAL SYSTEMS
COMPUTATION SHEET

SHEET NO. 4 OF 4

PROJECT NO 17-7958 SPONSOR:
SUBJECT VACUUM TEST of 8P12B, 6UF30, & 8UA12B
BY D.C. JOHNSON DATE: 10/28 19 88 CHECKED BY DATE CHECKED 19

Supervisory Test Engineer: J.P. HARRELL

note: 6UF10A BURST DURING THE KEROSENE TEST AND WAS THEREFORE NOT INCLUDED IN THE VACUUM TEST

8P12B

- HELD 15" VACUUM (MIN)
- NO visible weeping, blistering, delamination or collapse
- HOSE passed by J.P. Harrell

8UA12B

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE passed by J.P. Harrell

6UA30
~~6UF30~~ DW

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. Harrell

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

Test Results Worksheet
Hose 8P12B

Axial Load vs. Elongation Test

Lo = 145.50 "
Nipple = 18.88 "

Load (lbs)	Load Cell (lbs)	Actual Load (lbs)	Hyd. Press. (psi)	Actual Load (lbs)	Eng. Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongation (%)
0	0	0	0	0	0.00	145.50	107.75	0.00%
5000	5853	5162	92	5066	130.36	154.75	117.00	8.58%
10000	11241	10045	169	9983	253.69	168.00	130.25	20.88%
15000	16535	14963	247	14961	377.88	175.25	137.50	27.61%
0	5	0	0	0	0.00	149.50	111.75	3.71%

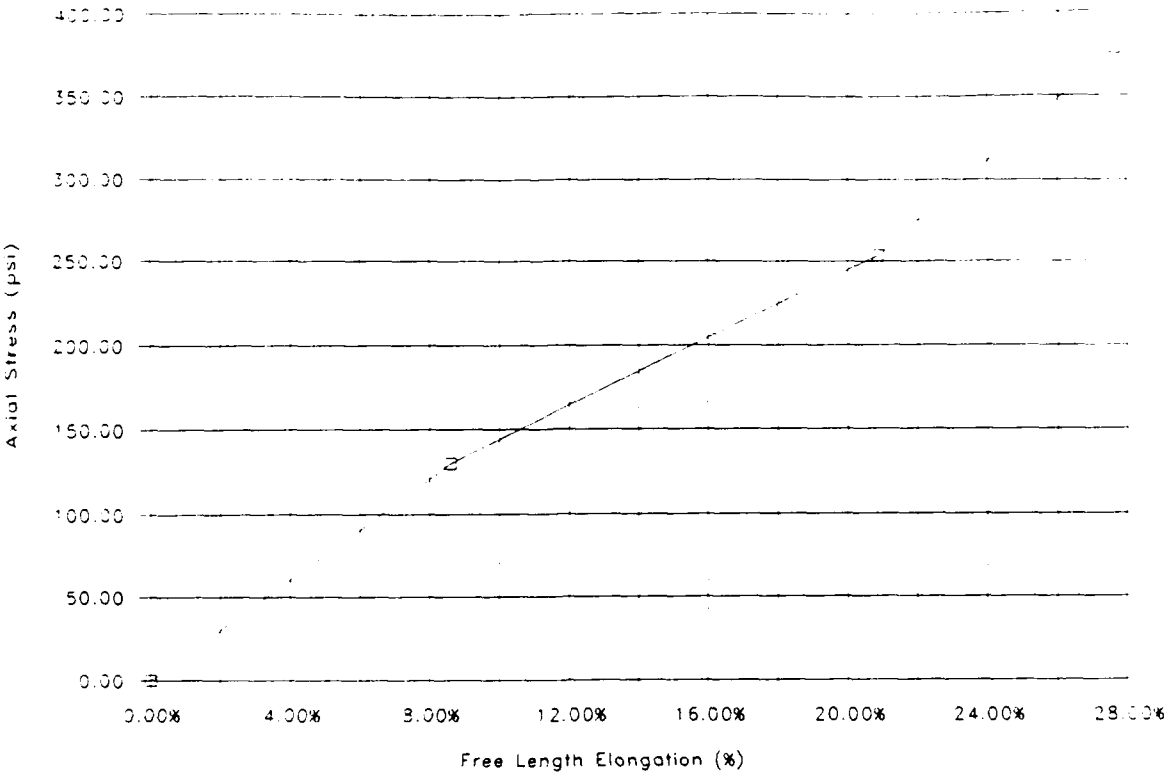
Load (lbs)	D1 (in)	D2 (in)	D3 (in)	D4 (in)	D5 (in)	Avg (in)	Avg X-Sect (sq-in)
0	10.98	10.30	10.45	10.24	11.15	10.33	39.60
5000	10.60	9.68	9.89	9.57	10.82	9.71	
10000	9.79	8.80	9.13	8.62	10.03	8.85	
15000	9.27	8.26	8.65	8.04	9.56	8.32	
(After 1hr)							
0	10.81	10.06	10.22	9.98	10.99	10.09	

Axial Stength Test

	Hyd Press (psi)	Axial Load (lbs)
Expected Tensile Strength =		55000
Actual Tensile Strength =	1902	119969

Axial Stress vs. Elongation

Hose BP-2B



Crush Test — BP12B

I.D. = 7.5 "

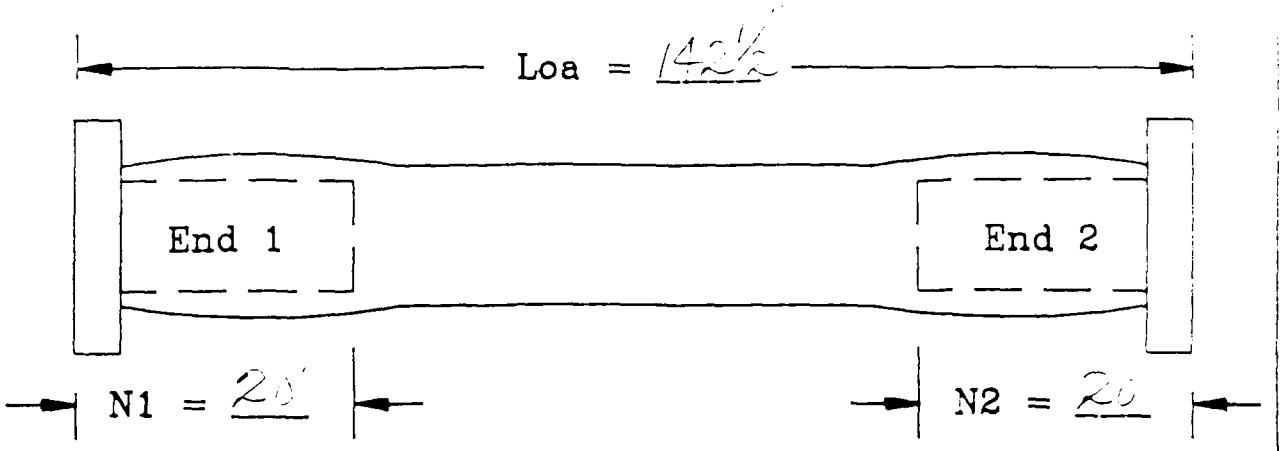
Crush (%)	Deflect (in)	Req'd Load (lbs)	Set (in)	I.D. Recovery (%)
10%	0.75	760	0.08	98.93%
20%	1.50	1112	0.15	98.00%
30%	2.25	1308	0.21	97.20%
40%	3.00	1496	0.29	96.13%
50%	3.75	1664	0.38	94.93%
60%	4.50	1844	0.43	94.27%
70%	5.25	2032	0.49	93.47%
80%	6.00	2252	0.55	92.67%
90%	6.75	2356	0.60	92.00%
100%	7.50	2512	0.65	91.33%
After 5 min.	-		0.50	93.33%

Data Package for Uniroyal Sample 8UA12A

Acceptance Test Data Sheet

Data Sheet No. 004

Hose I.D. Code [illegible]



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	10.625"
45.0"	9.972"
72.0"	9.953"
96.0"	9.932"
120.0"	10.460"

Signature [illegible] Date

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
~~6UF30~~	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
~~6UF30~~	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
~~6UF30~~	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

Test Results Worksheet for 8UA12A

Axial Load vs. Elongation Test — 8UA12A

Lo = 143.63 "
Nipple = 20.00 "

Load (lbs)	Load Cell	Actual Load (lbs)	Hyd. Press.	Actual Load (lbs)	Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongatio (%)
0	0	0	0	0	0.00	143.63	103.63	0.00%
5000	5441	4792	91	5002	164.76	145.38	105.38	1.69%
10000	10528	9393	171	10111	322.94	146.81	106.81	3.08%
15000	15549	14037	250	15152	482.60	149.25	109.25	5.43%
20000	20568	18806	332	20382	646.58	154.50	114.50	10.49%
25000	25600	23725	415	25674	815.70	158.75	118.75	14.60%
0	0	0	0	0	0.00	144.38	104.38	0.72%

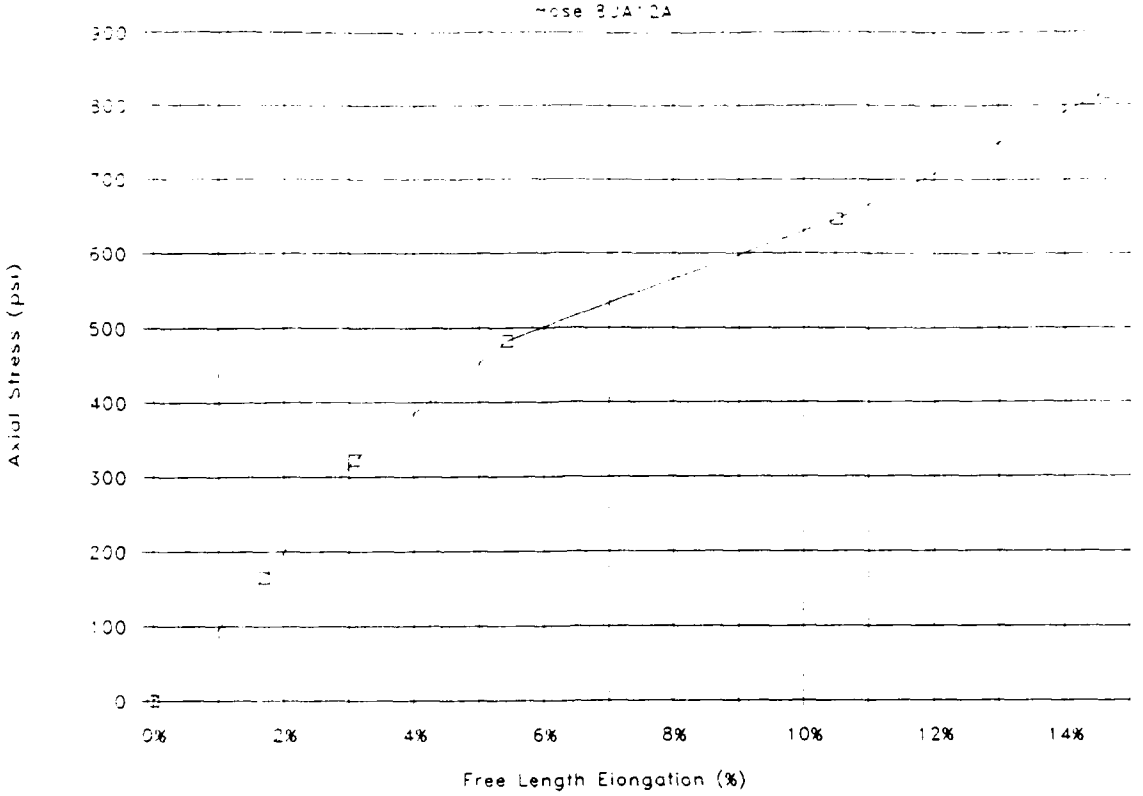
Load (lbs)	D1 (in)	D2 (in)	D3 (in)	D4 (in)	D5 (in)	Avg (in)	Avg X-Sect (sq-in)
0	10.63	9.97	9.95	9.93	10.46	9.95	29.09
5000	10.49	9.88	9.88	9.85	10.30	9.87	
10000	10.41	9.79	9.80	9.78	10.18	9.79	
15000	10.23	9.65	9.67	9.65	9.99	9.66	
20000	9.63	8.84	9.03	8.98	9.55	8.95	
25000	9.19	8.34	8.46	8.44	9.18	8.41	
(After 1hr)							
0	10.58	9.94	9.93	9.90	10.40	9.92	

Hydrostatic and Burst Test

Expected Burst Pressure = 1600 PSI
Actual Burst Pressure = 1695 PSI

Axial Stress vs. Elongation

Hose 8JA12A



8UA12A

Kink Test

Intrnl Press (psi)	X (in)	Y (in)	R (in)	Req'd Pull (lbs)
0	109.00	32.00	32.00	210
25	50.75	52.00	11.00	---
50	51.75	52.00	13.00	---
100		***No Kink***		

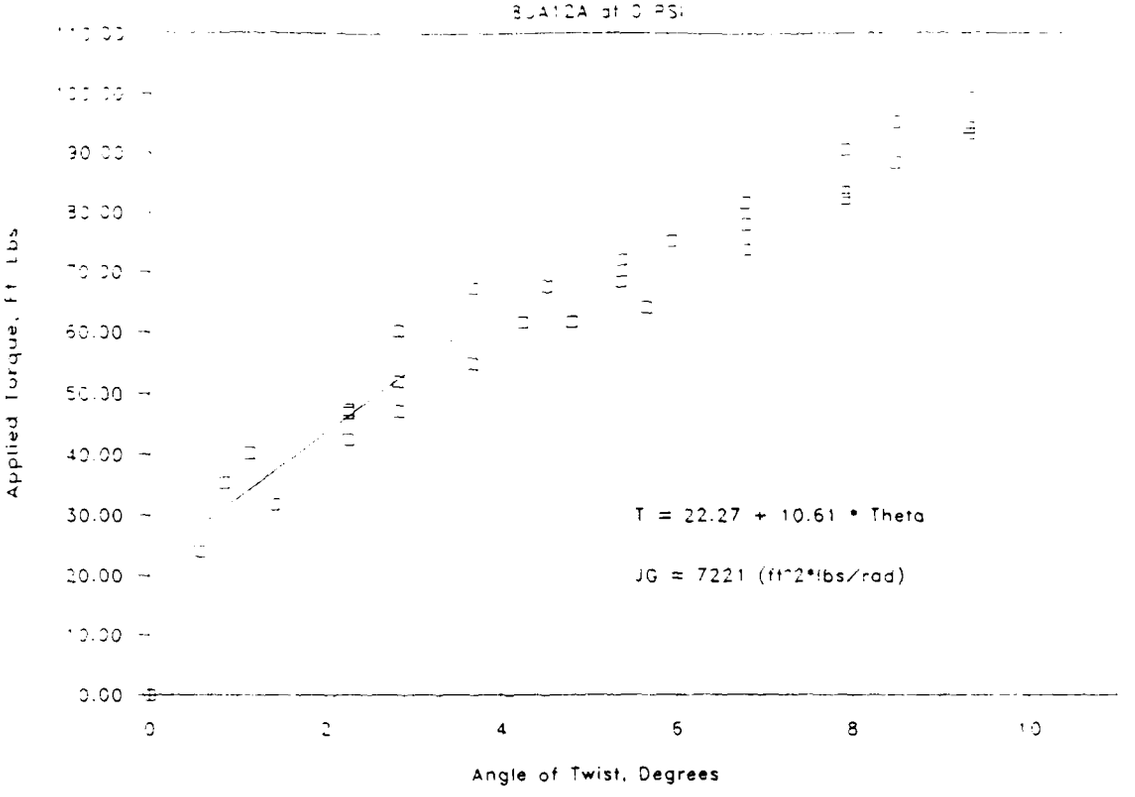
Torsional Stiffness Test

0 PSI Internal Pressure - RAW DATA: 8UA12A

Rotation (MM)	Rotation (Deg)	Run 1 Hyd Press (PSI)	Run 1 Torque (Ft-Lb)	Run 2 Hyd Press (PSI)	Run 2 Torque (Ft-Lb)	Run 3 Hyd Press (PSI)	Run 3 Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
2	0.564					99	24.0
3	0.846			146	35.4		
4	1.129	166	40.2				
5	1.411					131	31.7
8	2.257	193	46.8	195	47.3	175	42.4
10	2.821	248	60.1	214	51.9	194	47.0
13	3.668	277	67.1			226	54.8
15	4.232			254	61.6		
16	4.514	279	67.6				
17	4.796					254	61.6
19	5.361	282	68.4	297	72.0		
20	5.643					264	64.0
21	5.925	310	75.2				
24	6.771	337	81.7	322	78.1	304	73.7
28	7.900	374	90.7	345	83.6	340	82.4
30	8.464	393	95.3			365	88.5
33	9.310	417	101.1	385	93.3	389	94.3
36	10.157			413	100.1		

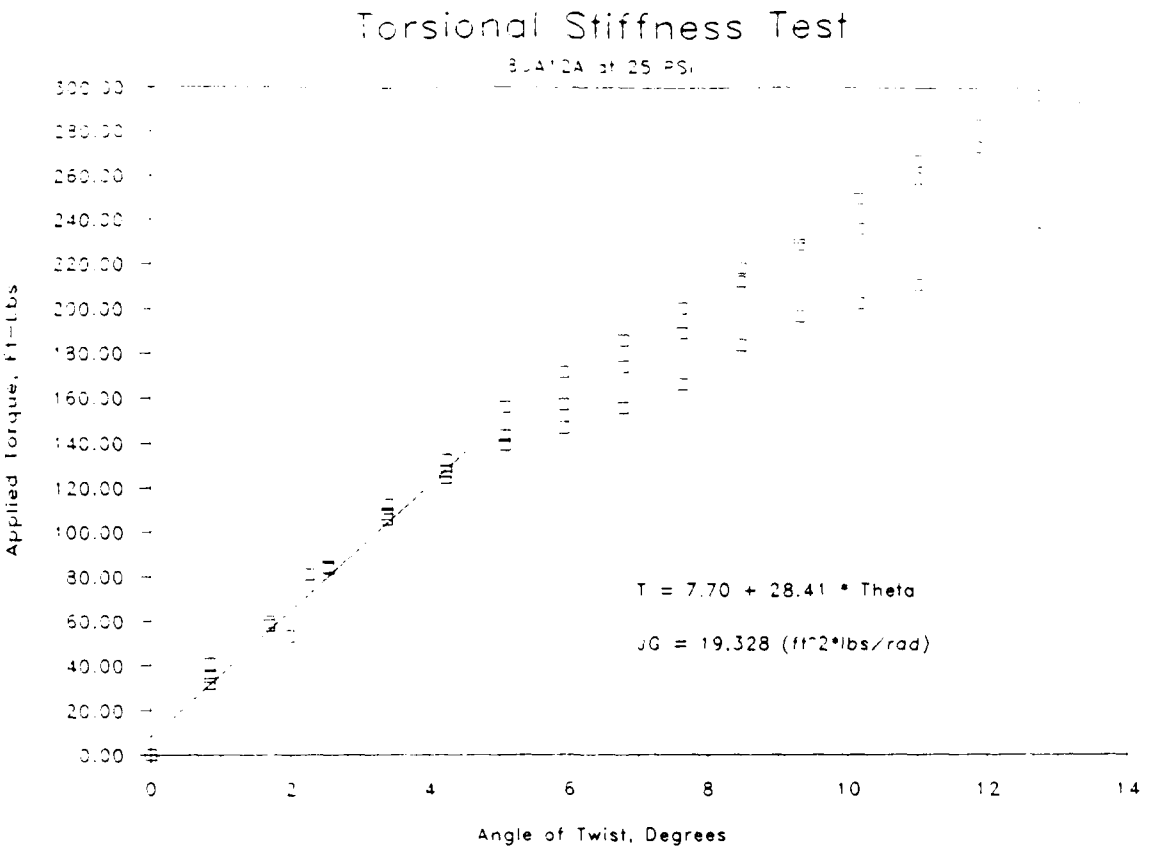
Torsional Stiffness Test

BLA12A at 0 PSI



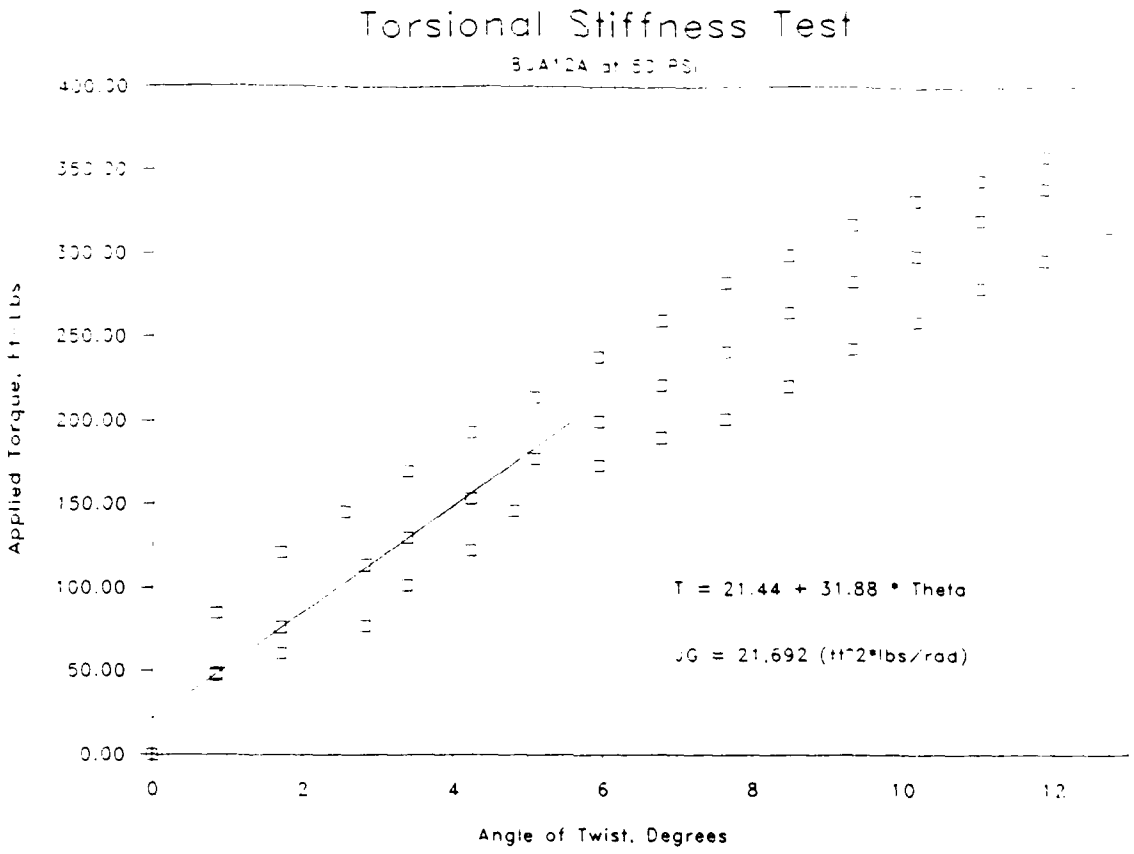
25 PSI Internal Pressure - RAW DATA 8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846	133	32.2	146	35.4	170	41.2
6	1.693	240	58.2			246	59.6
7	1.975			220	53.3		
8	2.257					333	80.7
9	2.539	345	83.6	348	84.4		
12	3.386	446	108.1	464	112.5	436	105.7
15	4.232	525	127.3	545	132.1	513	124.4
18	5.078	573	138.9	642	155.7	590	143.0
21	5.925	604	146.4	706	171.2	647	156.9
24	6.771	641	155.4	766	185.7	718	174.1
27	7.618	685	166.1	825	200.0	779	188.9
30	8.464	757	183.5	900	218.2	875	212.2
33	9.310	810	196.4	943	228.7	958	232.3
36	10.157	835	202.5	973	235.9	1029	249.5
39	11.003	870	210.9	1068	259.0	1100	266.7
42	11.850	945	229.1	1126	273.0	1188	288.1
45	12.696	965	234.0			1223	296.6
47	13.260			1218	295.3		


Torsional Stiffness Test
B-A12A at 25 PSI
Applied Torque, ft-lbs
300.00
280.00
260.00
240.00
220.00
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
2
4
6
8
10
12
14
Angle of Twist, Degrees
T = 7.70 + 28.41 * Theta
JG = 19.328 (ft^2*lbs/rad)

50 PSI Internal Pressure - RAW DATA 8UA12A

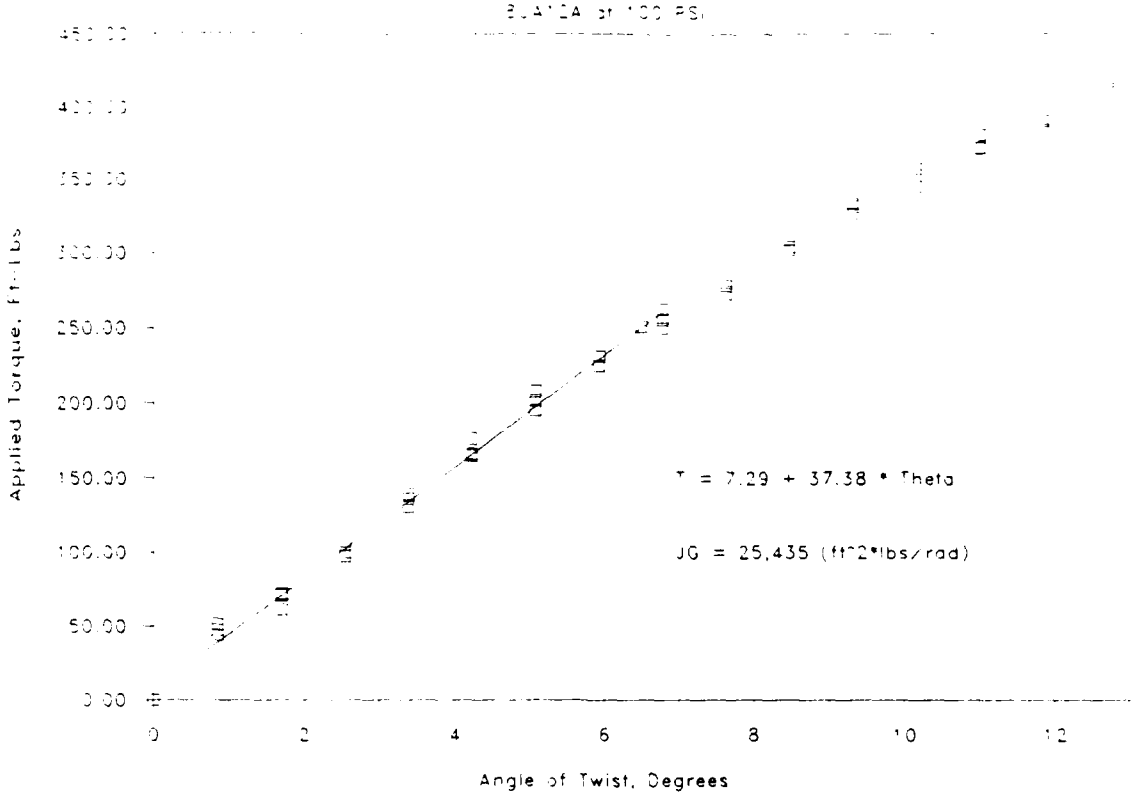
		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846	350	84.9	200	48.5	197	47.7
6	1.693	500	121.2	314	76.1	250	60.6
9	2.539	600	145.5				
10	2.821			468	113.5	318	77.1
12	3.386	700	169.7	536	130.0	418	101.3
15	4.232	796	193.0	631	153.0	504	122.2
17	4.796					601	145.7
18	5.078	880	213.4	730	177.0		
21	5.925	980	237.6	821	199.1	714	173.1
24	6.771	1069	259.2	910	220.6	781	189.4
27	7.618	1163	282.0	992	240.5	828	200.8
30	8.464	1230	298.2	1088	263.8	907	219.9
33	9.310	1306	316.7	1165	282.5	1000	242.5
36	10.157	1368	331.7	1231	298.5	1068	259.0
39	11.003	1416	343.4	1317	319.3	1149	278.6
42	11.850	1473	357.2	1394	338.0	1218	295.3
45	12.696					1300	315.2


Torsional Stiffness Test
BLADE A @ 60 PSI
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Applied Torque, ft-lbs
0
2
4
6
8
10
12
Angle of Twist, Degrees
T = 21.44 + 31.88 * Theta
JG = 21,692 (ft^2*lbs/rad)

100 PSI Internal Pressure - RAW DATA 8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846	195	47.3	181	43.9	212	51.4
6	1.693	252	61.1	296	71.8	292	70.8
9	2.539	400	97.0	434	105.2	411	99.6
12	3.386	538	130.4	573	138.9	560	135.8
15	4.232	680	164.9	685	166.1	727	176.3
18	5.078	803	194.7	830	201.2	855	207.3
21	5.925	925	224.3	950	230.3		
23	6.489					1033	250.5
24	6.771	1028	249.3	1052	255.1	1081	262.1
27	7.618	1125	272.8	1147	278.1	1162	281.8
30	8.464	1257	304.8	1249	302.9	1279	310.1
33	9.310	1353	328.1	1373	332.9	1381	334.9
36	10.157	1429	346.5	1461	354.3	1480	358.9
39	11.003	1539	373.2	1537	372.7	1574	381.7
42	11.850	1590	385.5	1614	391.4	1657	401.8
45	12.696	1700	412.2			1721	417.3

Torsional Stiffness Test

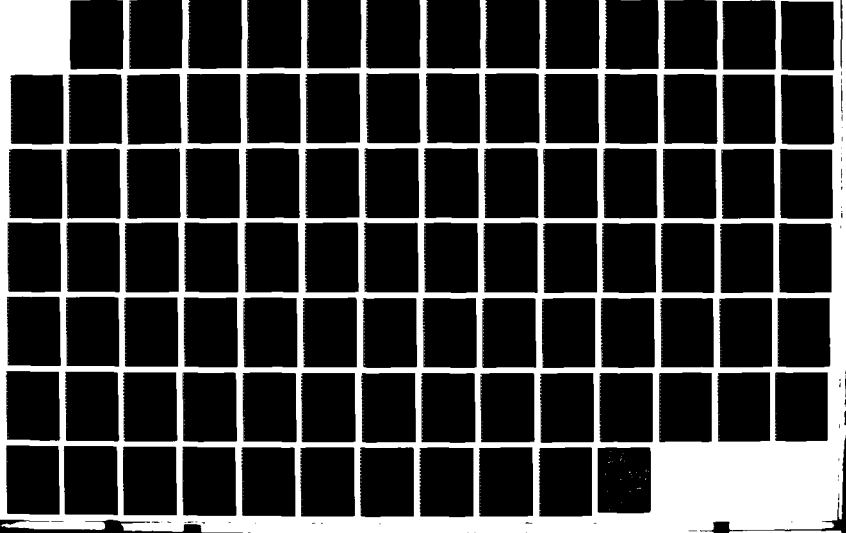


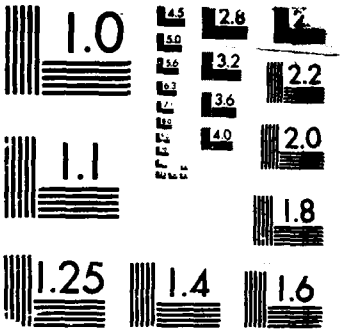
150 PSI Internal Pressure - RAW DATA 8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846	233	56.5	267	64.7	226	54.8
6	1.693	286	69.3	337	81.7	296	71.8
9	2.539	467	113.2	481	116.6	479	116.1
12	3.386	608	147.4	634	153.7	611	148.1
15	4.232	725	175.8	789	191.3	784	190.1
18	5.078	890	215.8	915	221.9	910	220.6
21	5.925	1015	246.1	1070	259.4	1047	253.9
24	6.771	1169	283.5	1195	289.8	1166	282.7
27	7.618	1243	301.4	1299	315.0	1308	317.2
30	8.464	1394	338.0	1445	350.4	1435	348.0
33	9.310	1533	371.7	1571	380.9	1552	376.3
36	10.157	1633	396.0	1674	405.9	1675	406.2
39	11.003	1759	426.5	1812	439.4	1815	440.1
42	11.850	1857	450.3	1914	464.1	1908	462.7
45	12.696	1909	462.9	2000	485.0	2000	485.0
48	13.542	1965	476.5	2117	513.3	2065	500.7
51	14.389	2000	485.0	2166	525.2	2108	511.2

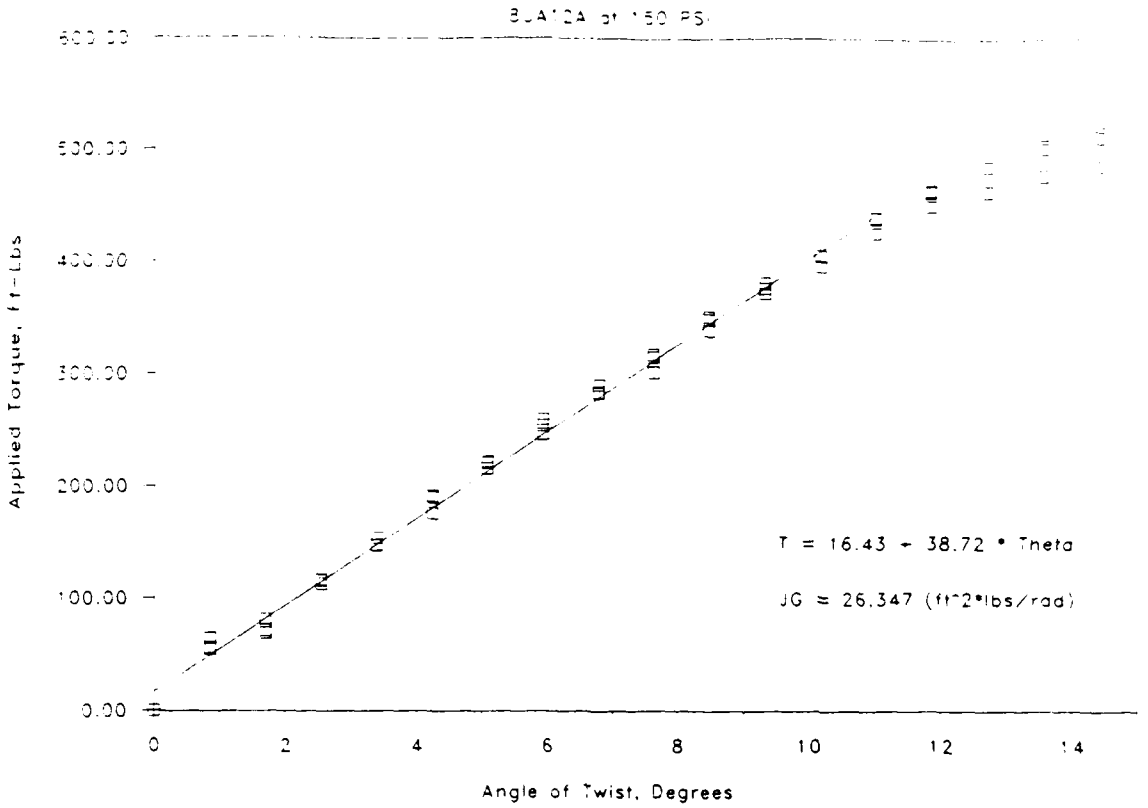
AD-A206 280 DETERMINATION OF A PERFORMANCE BASELINE FOR THE NONDESTRUCTIVE EVALUATION OF OFFSHORE PETROLEUM HOSES (U) SOUTHWEST RESEARCH INST SAN ANTONIO TX 2/2

UNCLASSIFIED J P HARRELL ET AL. JAN 89 F/G 13/11 NL




1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
4.5
5.0
5.6
6.3

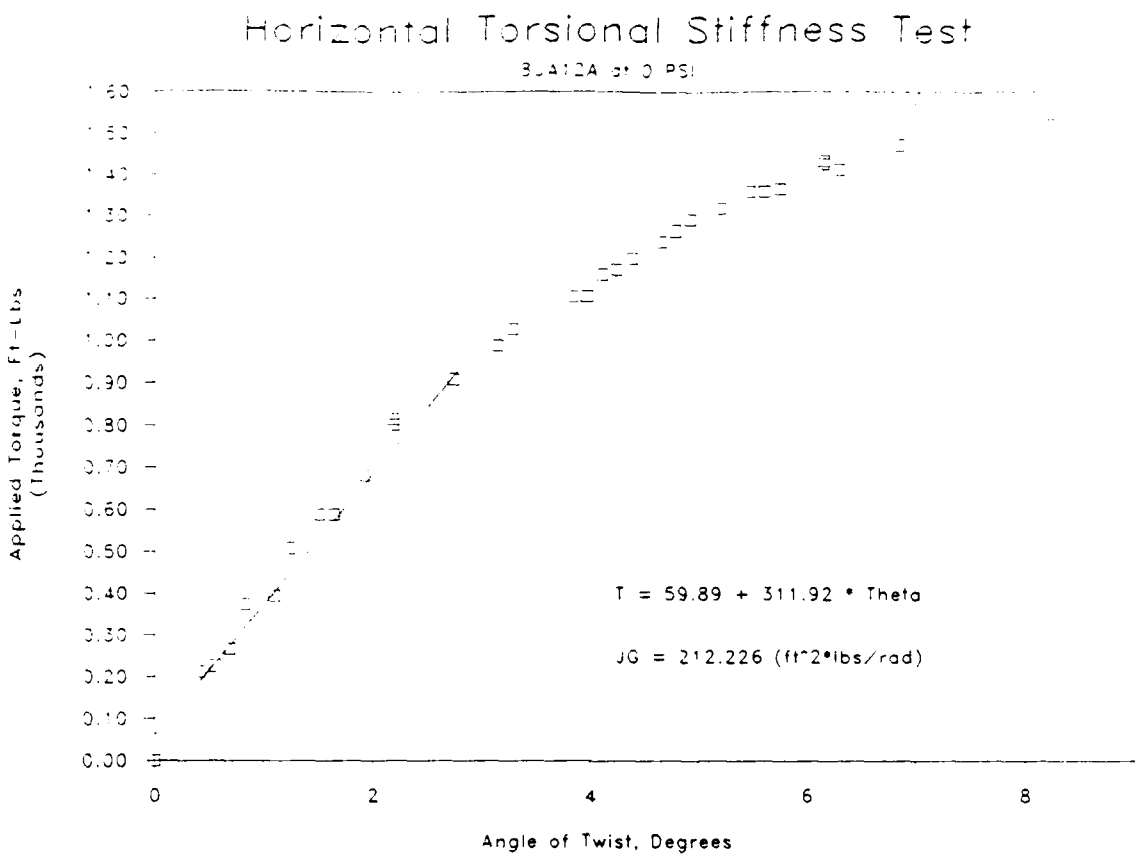
Torsional Stiffness Test



Horizontal Torsional Stiffness Test

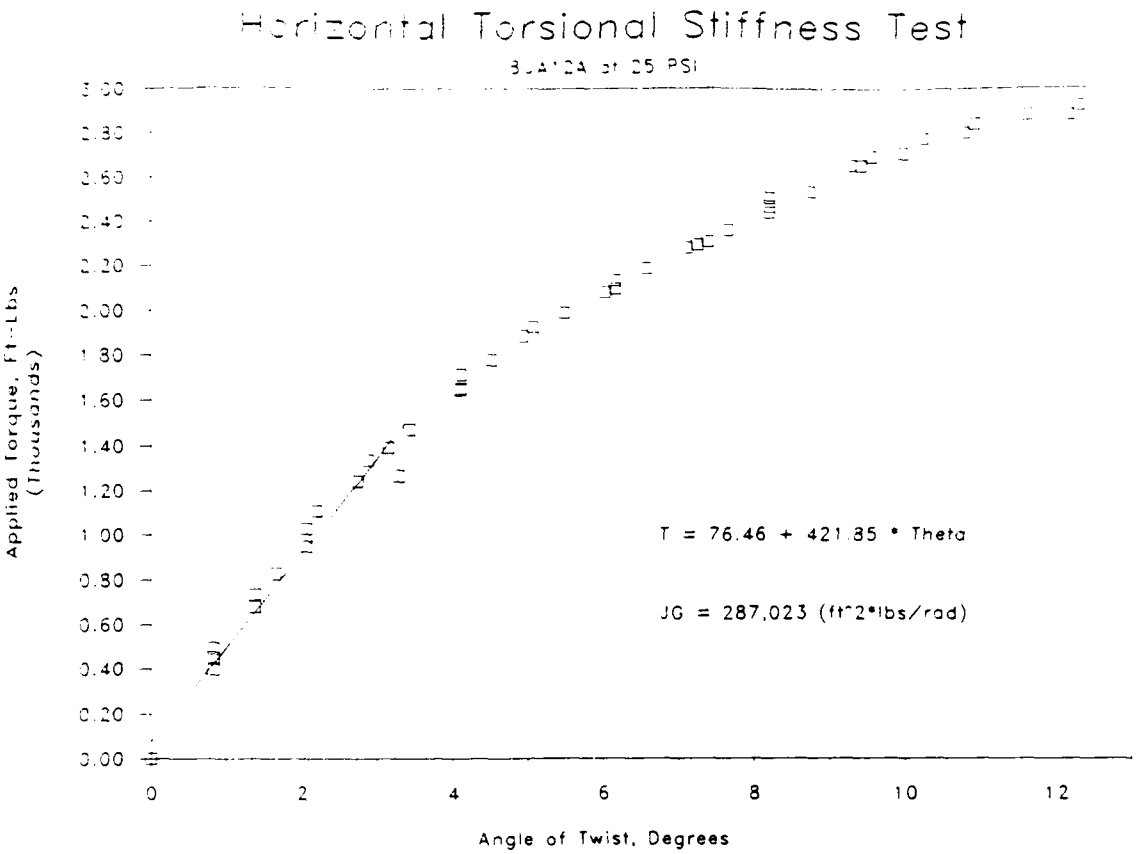
0 PSI Internal Pressure - RAW DATA: 8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
3	0.410			160	213.3		
4	0.547					170	226.7
5	0.684	200	266.7				
6	0.820			280	373.3		
8	1.094					295	393.3
9	1.230	380	506.7				
11	1.504			440	586.7		
12	1.641					440	586.7
14	1.914	510	680.0				
16	2.187			610	813.3	600	800.0
20	2.734	680	906.7				
23	3.144	740	986.7				
24	3.281			770	1026.7	770	1026.7
28	3.828			830	1106.7		
29	3.965					830	1106.7
30	4.101	870	1160.0				
31	4.238					880	1173.3
32	4.375			900	1200.0		
34	4.648	930	1240.0				
35	4.785					950	1266.7
36	4.922			970	1293.3		
38	5.195	990	1320.0				
40	5.468					1020	1360.0
41	5.605			1020	1360.0		
42	5.742	1025	1366.7				
45	6.152			1070	1426.7	1075	1433.3
46	6.289	1060	1413.3				
50	6.836			1105	1473.3	1105	1473.3
51	6.972	1190	1586.7				
60	8.203	1160	1546.7				


Horizontal Torsional Stiffness Test
B-A12A at 0 PSI
Applied Torque, Ft-Lbs
(Thousands)
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
2
4
6
8
Angle of Twist, Degrees
T = 59.89 + 311.92 * Theta
JG = 212.226 (ft^2*lbs/rad)

25 PSI Internal Pressure - RAW DATA: 8UA12A

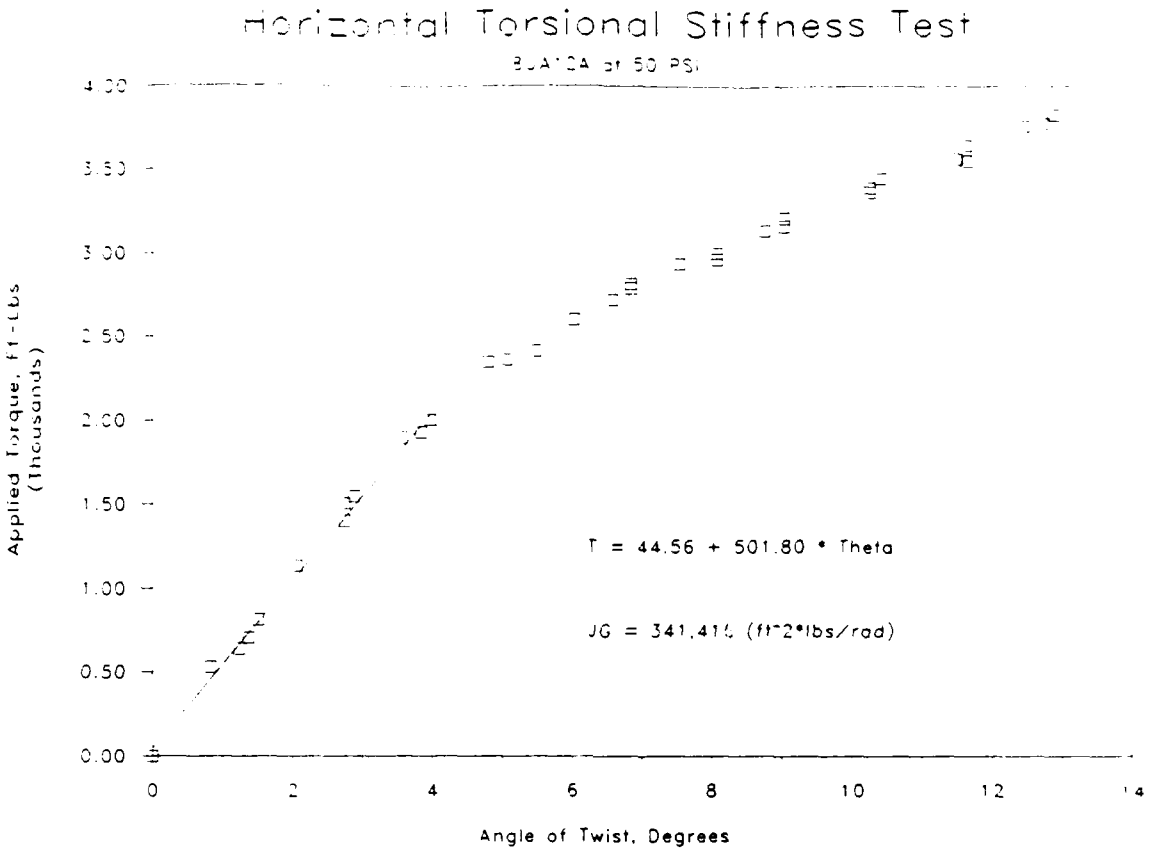
		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
6	0.820	340	453.3	370	493.3	300	400.0
10	1.367	510	680.0	550	733.3		
12	1.641					620	826.7
15	2.051	710	946.7	770	1026.7		
16	2.187					830	1106.7
20	2.734	930	1240.0				
21	2.871			1000	1333.3		
23	3.144					1040	1386.7
24	3.281	945	1260.0				
25	3.418			1100	1466.7		
30	4.101	1235	1646.7	1280	1706.7	1230	1640.0
33	4.511	1330	1773.3				
36	4.922					1410	1880.0
37	5.058			1440	1920.0		
40	5.468	1490	1986.7				
44	6.015	1560	2080.0				
45	6.152			1600	2133.3	1570	2093.3
48	6.562	1640	2186.7				
52	7.109	1710	2280.0				
53	7.246					1720	2293.3
54	7.382			1730	2306.7		
56	7.656	1770	2360.0				
60	8.203	1830	2440.0	1880	2506.7	1850	2466.7
64	8.750	1900	2533.3				
68	9.296	1990	2653.3				
69	9.433					1990	2653.3
70	9.570			2020	2693.3		
73	9.980	2030	2706.7				
75	10.253			2080	2773.3		
79	10.800					2100	2800.0
80	10.937			2130	2840.0		
85	11.620			2160	2880.0		
89	12.167					2160	2880.0
90	12.304			2190	2920.0		


Horizontal Torsional Stiffness Test
BLA'2A at 25 PSI
Applied Torque, Ft-Lbs
(Thousands)
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0
2
4
6
8
10
12
Angle of Twist, Degrees
T = 76.46 + 421.85 * Theta
JG = 287,023 (ft^2*lbs/rad)

50 PSI Internal Pressure - RAW DATA:

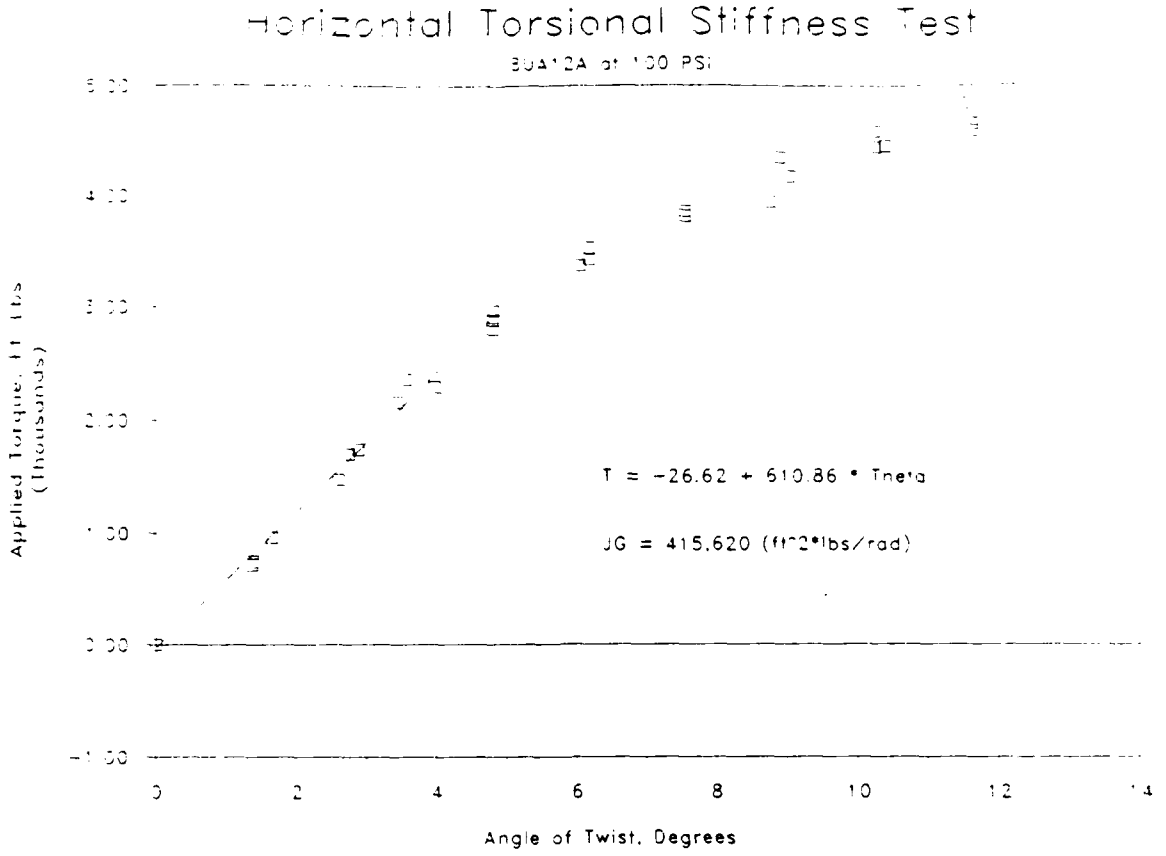
8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
6	0.820	400	533.3				
9	1.230					480	640.0
10	1.367			530	706.7		
11	1.504	610	813.3				
15	2.051	850	1133.3				
20	2.734			1050	1400.0	1130	1506.7
21	2.871	1160	1546.7				
26	3.554	1420	1893.3				
28	3.828			1445	1926.7		
29	3.965					1500	2000.0
35	4.785	1760	2346.7				
37	5.058			1770	2360.0		
40	5.468					1810	2413.3
44	6.015	1950	2600.0				
48	6.562			2040	2720.0		
50	6.836	2110	2813.3			2090	2786.7
55	7.519			2200	2933.3		
59	8.066	2250	3000.0			2220	2960.0
64	8.750			2350	3133.3		
66	9.023	2405	3206.7			2370	3160.0
75	10.253	2540	3386.7			2520	3360.0
76	10.390			2580	3440.0		
84	11.484	2670	3560.0				
85	11.620			2730	3640.0	2660	3546.7
91	12.441	2820	3760.0				
93	12.714					2830	3773.3
94	12.851			2870	3826.7		
101	13.808					2960	3946.7


Horizontal Torsional Stiffness Test
BLADE at 50 PSI
Applied Torque, ft-lbs (Thousands)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
2
4
6
8
10
12
14
Angle of Twist, Degrees
T = 44.56 + 501.80 * Theta
JG = 341,414 (ft^2*lbs/rad)

100 PSI Internal Pressure - RAW DATA: 8UA12A

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)	Cable Tension (Lbs)	Torque (Ft-Lb)
0	0.000	0	0.0	0	0.0	0	0.0
10	1.367	540	720.0			560	746.7
12	1.641			720	960.0		
19	2.598	1100	1466.7				
20	2.734					1270	1693.3
21	2.871			1300	1733.3		
25	3.418			1610	2146.7		
26	3.554					1760	2346.7
29	3.965	1710	2280.0				
35	4.785	2160	2880.0	2100	2800.0	2220	2960.0
44	6.015			2530	3373.3		
45	6.152	2570	3426.7			2650	3533.3
55	7.519	2900	3866.7	2870	3826.7		
64	8.750			2970	3960.0		
65	8.886					3270	4360.0
66	9.023	3140	4186.7				
75	10.253			3340	4453.3	3450	4600.0
76	10.390	3350	4466.7				
84	11.484					3630	4840.0
85	11.620	3450	4600.0	3500	4666.7		
96	13.124	3660	4880.0				


Horizontal Torsional Stiffness Test
T = -26.62 + 610.86 * Theta
JG = 415.620 (ft^2*lbs/rad)
Angle of Twist, Degrees

Crush Test — 8UA12A

I.D. = 7.875 "

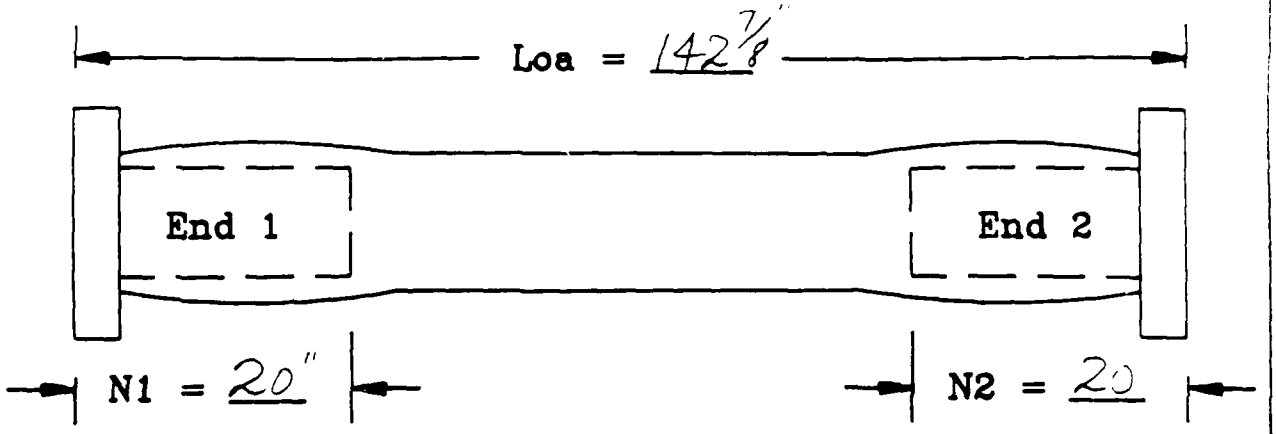
Crush (%)	Deflect (in)	Req'd Load (lbs)	Set (in)	I.D. Recovery (%)
10%	0.79	540	0.05	99.37%
20%	1.58	832	0.10	98.73%
30%	2.36	960	0.16	97.97%
40%	3.15	1076	0.20	97.46%
50%	3.94	1196	0.27	96.57%
60%	4.73	1364	0.31	96.06%
70%	5.51	1560	0.38	95.17%
80%	6.30	1748	0.39	95.05%
90%	7.09	1880	0.40	94.92%
100%	7.88	2116	0.41	94.79%
After 5 min.	-		0.30	96.19%

Data Package for Uniroyal Sample 8UA12B

Acceptance Test Data Sheet

Data Sheet No. 005

Hose I.D. Code 8 1A 2



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	10.648"
48.0"	9.965"
72.0"	9.975"
96.0"	9.960"
120.0"	10.636"

Signature: Joe P. Canelli

Date: 9/27/88

SOUTHWEST RESEARCH INSTITUTE
DEPARTMENT OF STRUCTURAL AND MECHANICAL SYSTEMS
COMPUTATION SHEET

SHEET ___ OF ___

PROJECT NO 17-7152 SPONSOR
SUBJECT VACUUM TEST OF EP1ZB, 6UF3C, & 6UA1ZB
BY D[illegible] DATE 6/25/19 CHECKED BY DATE CHECKED 19

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

SUPERVISORY TEST ENGINEER: J.P. HARRELL

NOTE: 6UF1CA BURST DURING THE REFERENCE TEST AND WAS THEREFORE NOT INCLUDED IN THE VACUUM TEST

EP1ZB

- HELD 15" VACUUM (MIN)
- NO VISIBLE WEEPING, BLISTERING, DELAMINATION OR COLLAPSE
- HOSE PASSED BY J.P. HARRELL

6UA1ZB

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. HARRELL

~~6UF3C~~ 6UA30

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. HARRELL

KEROSENE TEST

HI - 6UA12B & ~~6UF30~~ 6UA30

LOW - 8P12B & 6UF10A

TIME	HI	LOW	
2230	1066	610	
2245	1065	604	
23:00	1061	599	6UF10A Blew apart at End B
23:17	1070	683	8P12B WASN't ~~open~~ pressurized @ 1st HR
23:30	1058	630	" now pressurized, just letting pressure settle
2345	1065	602	
2400	1064	599	
~~00~~15	1061	595	
~~00~~30	1058	594	
~~00~~45	1061	631	
1:00	1052	614	
1:15	1061	601	
1:30	1068	608	
1:45	1061	598	
2:00	1066	607	
2:15	1060	597	
2:30	1071	607	
2:45	1066	598	
3:00	1062	592	
3:15	1064	609	
3:30	1057	601	
3:45	1065	604	
4:00	1061	597	
4:15	1070	605	
4:30	534	598	
04:45	537	607	
05.00	537	601	
0515	536	609	
0530	535	604	(304) pressure reduced in 8P12B to 30
0545	533	307	
0600	531	309	
0615	530	304	
0630	534	304	
0645	533	304	
0700	532	303	

Date: 10/27/88

Signature: Dave Johnson / Joe Carrillo

(SwR 17) Rev 6/75

KEROSENE TEST

TIME	HI	LOW	
0715	531	302	
0730	529	301	
0745	535	300	
0800	532	303	
0815	529	302	
0835	538	301	
0900	539	302	
0915	540	302	
0930	541	302	
1000	535	307	
1015	538	309	
1030	541	312	- BLED BOTH DOWN
1045	532	305	
1100	537	309	
11:15	544	315	- Bled Both Down.
11:16	531	302	
11:30	537	309	
11:45	543	314	- Bled Both Down.
11:46	529	302	
12:02	536	312	
1212	529	302	Bled Both Down.
12:30	543	316	Bled Both Down.
12:31	529	299	
12:55	556	329	Bled Both Down.
12:57	528	300	
13:15	542	322	Bled off Both.
13:16	529	302	
1337	550	343	Bled both
1338	529	303	
1400	550	327	Bled both
14:21	528	302	
1420	550	327	
1430	533	306	
1440	544	316	
1500	470	312	End Test

Date: 10/28/98

Signature: D. W. Johnson

SwRI 171 Rev 6, 95

Test Results Worksheet
Hose 8UA128

Axial Load vs. Elongation Test

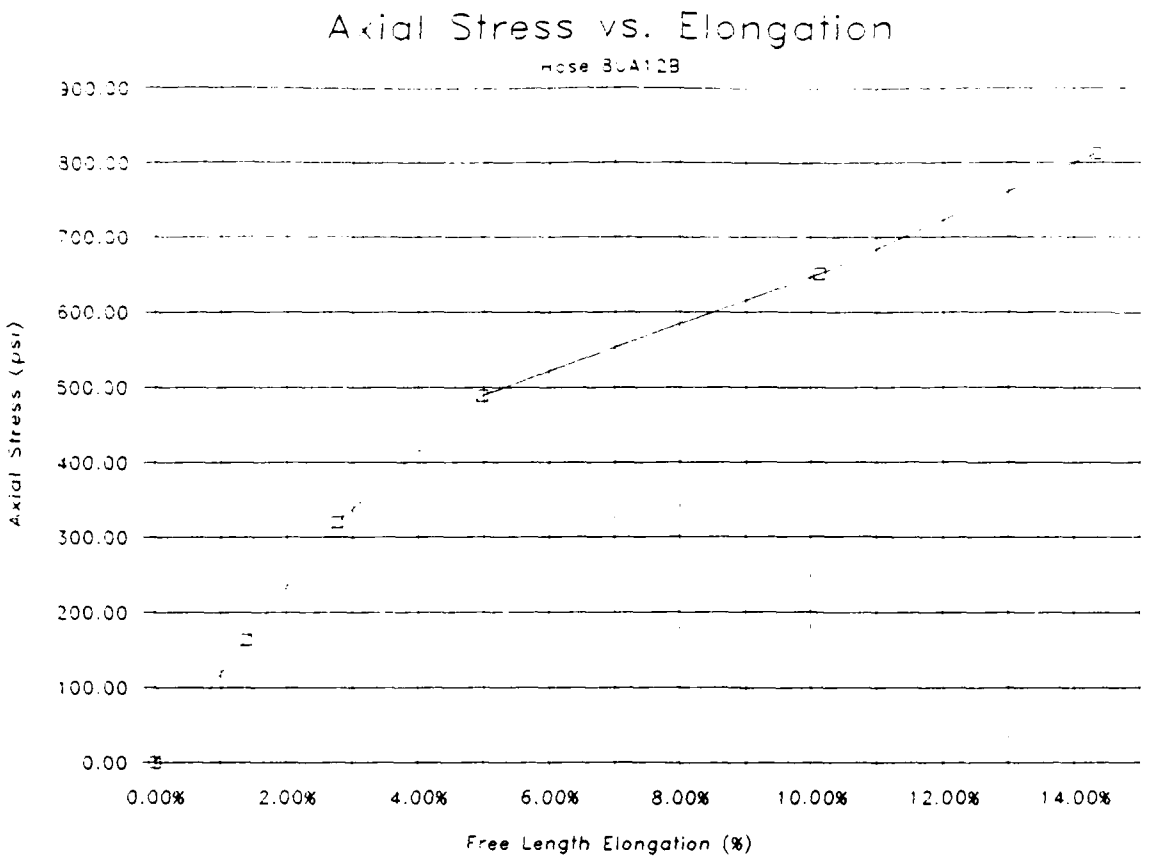
Lo = 144.313 "
Nipple = 20 "

Load (lbs)	Load Cell	Actual Load (lbs)	Hyd. Press.	Actual Load (lbs)	Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongation (%)
0	0	0	0	0	0.00	144.31	104.31	0.00%
5000	5430	4782	93	5130	163.77	145.75	105.75	1.38%
10000	10485	9354	169	9983	320.33	147.19	107.19	2.76%
15000	15801	14273	249	15088	488.79	149.50	109.50	4.97%
20000	20808	19038	329	20191	651.96	154.88	114.88	10.13%
25000	25606	23731	405	25036	812.70	159.25	119.25	14.32%
0	0	0	0	0	0.00	145.38	105.38	1.02%

Load (lbs)	D1 (in)	D2 (in)	D3 (in)	D4 (in)	D5 (in)	Avg (in)	Avg X-Sect (sq-in)
0	10.65	9.95	9.97	9.96	10.61	9.96	29.20
5000	10.55	9.88	9.92	9.91	10.50	9.90	
10000	10.45	9.81	9.84	9.83	10.39	9.83	
15000	10.28	9.69	9.73	9.55	10.20	9.66	
20000	9.75	9.06	9.11	8.97	9.64	9.05	
25000	9.27	8.41	8.36	8.36	9.34	8.37	
(After 1hr)							
0	10.59	9.91	9.92	9.91	10.56	9.91	

Axial Stength Test

	Hyd Press (PSI)	Axial Load (Lbs)
Expected Tensile Strength =		80000
Actual Tensile Strength =	1587	100073

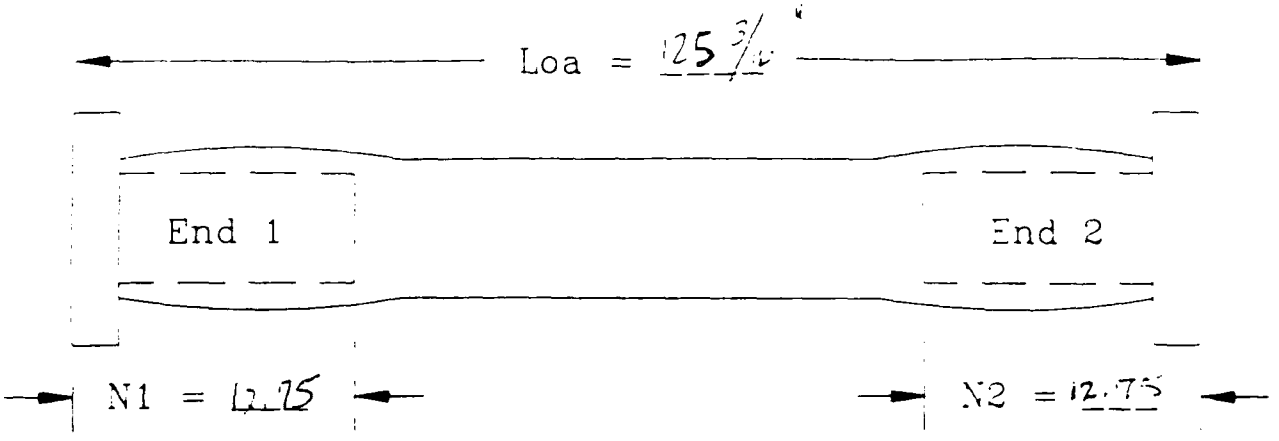

Axial Stress vs. Elongation
Hose BUA12B
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Axial Stress (psi)
0.00%
2.00%
4.00%
6.00%
8.00%
10.00%
12.00%
14.00%
Free Length Elongation (%)

Data Package for Uniroyal Sample 8UA10

Acceptance Test Data Sheet

Data Sheet No

Hose I.D. Code
E.U.A.I.C.



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
12" from END A (Inside edge of cap)	9.934"
Middle	9.979"
12" from END B (Inside edge of cap)	9.992"

Measurements taken from Actual Straight Part of Hose

SRI

Signature

Date

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
6UA30 ~~6UF30~~	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
6UA30 ~~6UF30~~	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
6UA30 ~~6UF30~~	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

Test Results Worksheet
Hose 8UA10

Axial Load vs. Elongation Test

Lo = 125.19
Nipple = 12.75 "

Load (lbs)	Load Cell	Actual Load (lbs)	Hyd. Press.	Actual Load (lbs)	Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongation (%)
0	0	0	0	0	0.00	125.19	99.69	0.00%
5000	5597	4932	90	4939	168.12	126.25	100.75	1.07%
10000	10432	9305	170	10047	317.20	127.50	102.00	2.32%
15000	15569	14055	249	15088	479.12	129.38	103.88	4.20%
20000	20796	19026	330	20255	648.55	132.00	106.50	6.83%
25000	25356	23484	406	25100	800.50	137.56	112.06	12.41%
0	0	0	0	0	0.00	125.75	100.25	0.56%

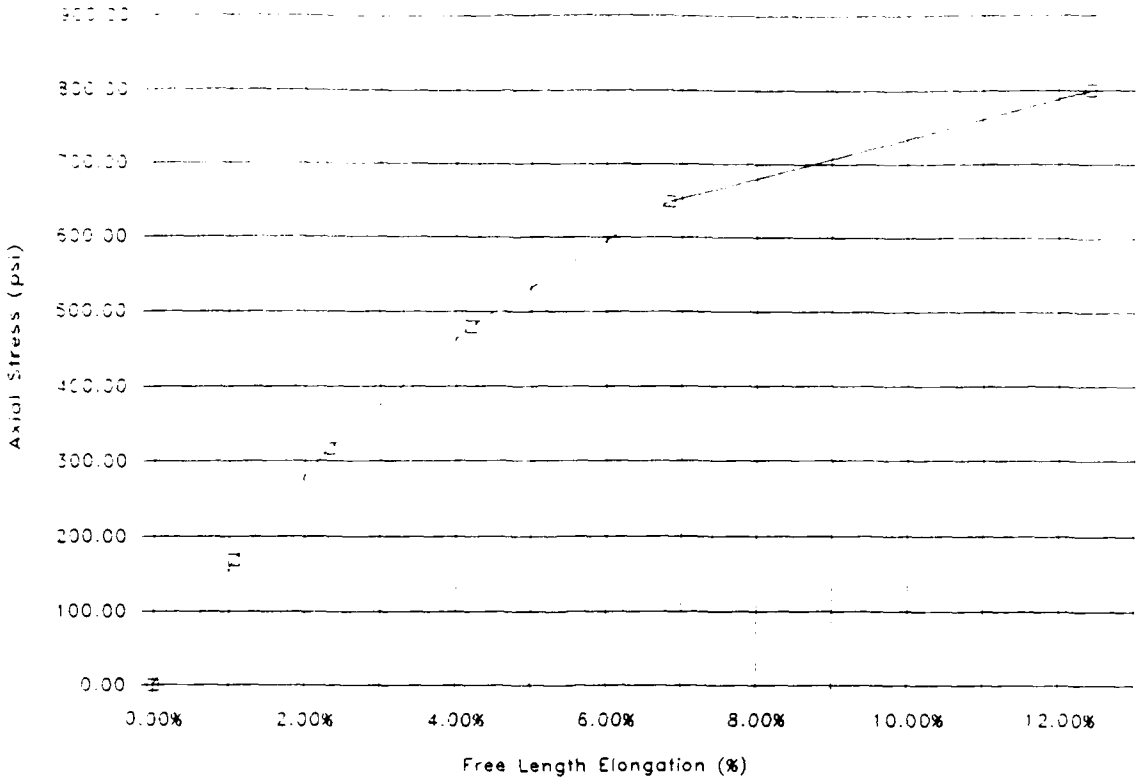
Load (lbs)	D1 (in)	D2 (in)	D3 (in)	Avg (in)	Avg X-Sect (sq-in)
0	9.93	9.98	9.99	9.97	29.34
5000	9.88	9.91	9.92	9.90	
10000	9.80	9.84	9.84	9.83	
15000	9.72	9.71	9.71	9.71	
20000	9.57	9.55	9.38	9.50	
25000	8.70	8.59	8.58	8.62	
(After 1hr)					
0	9.90	9.93	9.94	9.92	

Axial Stength Test

	Hyd Press (PSI)	Axial Load (Lbs)
Expected Tensile Strength =		80000
Actual Tensile Strength =	1250	78740

Axial Stress vs. Elongation

Hose B-A-10

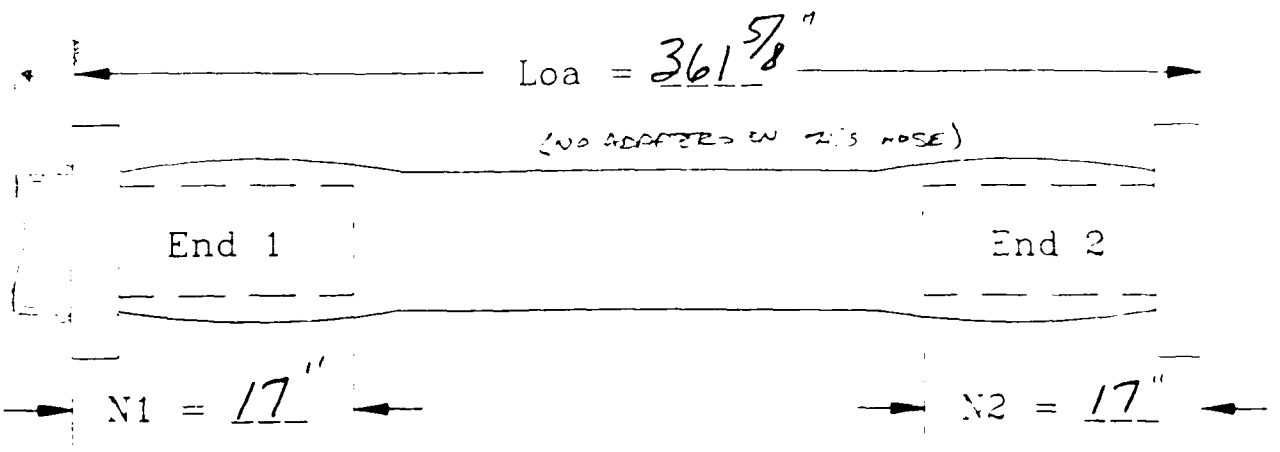


Data Package for Uniroyal Sample 6UA30

Acceptance Test Data Sheet

Data Sheet No. 2

Hose ID Code ~~[illegible]~~ 6UA30



Free Length = Loa − (N1 + N2) = 327.625

Dist from End 1	Outside Diameter
4'	7.854
180 3/4" FROM END "B"	7.800
4' FROM END "B"	7.868

Signature Joe Cavellis Date 10/24/88

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lo (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
~~6UF30~~ 6UA3C	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
~~6UF30~~ 6UA3C	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
~~6UF30~~ 6UA3C	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

SOUTHWEST RESEARCH INSTITUTE
DEPARTMENT OF STRUCTURAL AND MECHANICAL SYSTEMS
COMPUTATION SHEET

SHEET NO. 1 OF 1

PROJECT NO. 17-7958 SPONSOR
SUBJECT VACUUM TEST of 8P12B, 6UF30, & 8UA12B
BY [illegible] DATE 5/25 19 88 CHECKED BY DATE CHECKED 19

Supervisory Test Engineer: J.P. HARRELL

Note: 6UF10A BURST DURING THE KEROSENE TEST AND WAS THEREFORE NOT INCLUDED IN THE VACUUM TEST

8P12B

- HELD 15" VACUUM (MIN)
- NO visible weeping, blistering, delamination or collapse
- HOSE passed by J.P. Harrell

8UA12B

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE passed by J.P. Harrell

6UA30
~~6UF30~~ DW

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. Harrell

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas 78284

KEROSENE TEST

HI - 8UA12B & ~~6UF30~~ 6UA30

LOW - 8P12B & 6UF10A

TIME	HI	LOW	
2230	1066	610	
2245	1065	604	
23:00	1061	599	6UF10A Blew Apart of End "B"
23:17	1070	683	8P12B WASN't ~~often~~ pressurized @ 1st HR
23:30	1058	630	" over pressurized, just letting pres. settle
2345	1065	602	
2400	1064	599	
~~00~~15	1061	595	
~~00~~30	1058	594	
~~00~~45	1061	631	
1:00	1052	614	
1:15	1061	601	
1:30	1068	608	
1:45	1061	598	
2:00	1066	607	
2:15	1060	597	
2:30	1071	607	
2:45	1066	598	
3:00	1062	592	
3:15	1064	609	
3:30	1057	601	
3:45	1065	604	
4:00	1061	597	
4:15	1070	605	
4:30	534	598	
04:45	537	607	
05:00	537	601	
0515	536	609	
0530	535	604	(304) pressure reduced in 8P12B to 30 F
0545	533	307	
0600	531	309	
0615	530	304	
0630	534	304	
0645	533	304	
0700	532	303	

Date: 10/27/88

Signature: D.W. Johnson / Joe Canellis

(SwR 17) Rev 6/75

KEROSENE TEST

TIME	HI	LOW	
0715	531	302	
0730	529	301	
0745	535	300	
0800	532	303	
0815	529	302	
0835	538	301	
0900	539	302	
0915	540	302	
0930	541	302	
1000	535	307	
1015	538	309	
1030	541	312	- BLED BOTH DOWN
1045	532	305	
1100	537	309	
11.15	544	315	- Bled Both Down.
11:16	531	302	
11:30	537	309	
11:45	543	314	- Bled Both Down.
11:46	529	302	
12:02	536	312	
1212	529	302	Bled Both Down.
12:30	543	316	Bled Both Down.
12:31	529	299	
12:55	556	329	Bled Both Down
12:57	528	300	
13:15	542	322	Bled off Both.
13:16	529	302	
1337	550	343	Bled both
1338	529	303	
1400	550	327	Bled both
14:1	528	302	
1420	550	327	
1430	533	306	
1440	500	316	
1500	470	312	End Test

Date: 10/28/98

Signature: D. W. Johnson

(SwR 171) Rev 6/85

Test Results Worksheet

Hose ~~6UF-30~~ 6UA-3C

Kink Test

Intrnl Press (psi)	X (in)	Y (in)	R (in)	Req'd Pull (lbs)
0	88.00	148.00	34.00	---
25	54.50	82.25	27.00	---
50	---	---	12.00	---
100	---	---	7.00	---

Burst Test

Expected Burst Pressure = 1600 psi
Actual Burst Pressure = 1836 psi

Data Package for Uniroyal Sample 6UA12

Acceptance Test Data Sheet

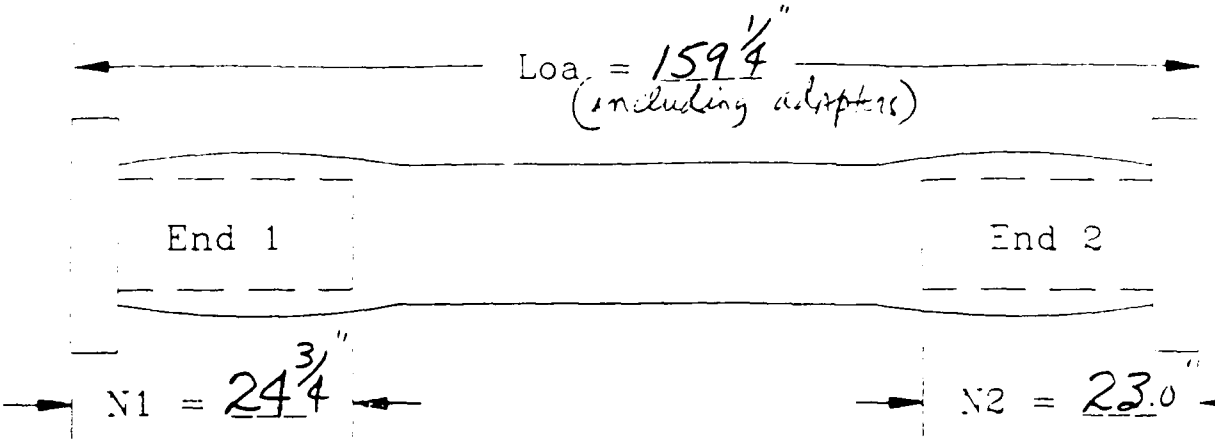
Data Sheet No

Hose I.D. Code

Loa = 159 1/4" (including adapters)

End 1 | End 2

N1 = 24 3/4" | N2 = 23.0"



Free Length = Loa − (N1 + N2) = 111.5"

Dist from End 1	Outside Diameter
4'	7.779
79" ℄	7.740
4' FROM END B	7.795

Signature: Joe Canellis

Date: 10/24/88

Test Results Worksheet

Hose ~~6UF12~~ 6UA12 DW

Axial Load vs. Elongation Test

Lo = 159.25 "

Nipple = 24.75 "(End A)

Nipple = 23.00 "(End B)

Load (lbs)	Load Cell (lbs)	Actual Load (lbs)	Hyd. Press. (psi)	Actual Load (lbs)	Eng. Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongatio (%)
0	0	0	0	0	0.00	159.25	111.50	0.00%
5000	5870	5177	90	4939	272.25	161.56	113.81	2.07%
10000	11195	10003	171	10111	526.04	167.44	119.69	7.34%
15000	16273	14717	249	15088	773.89	175.13	127.38	14.24%
20000	21365	19576	329	20191	1029.43	180.81	133[illegible]6	19.34%
25000	---	---	404	24973	1313.21	184.50	136.75	22.65%
0	95	10	0	0	0.00	165.38	117.63	5.49%

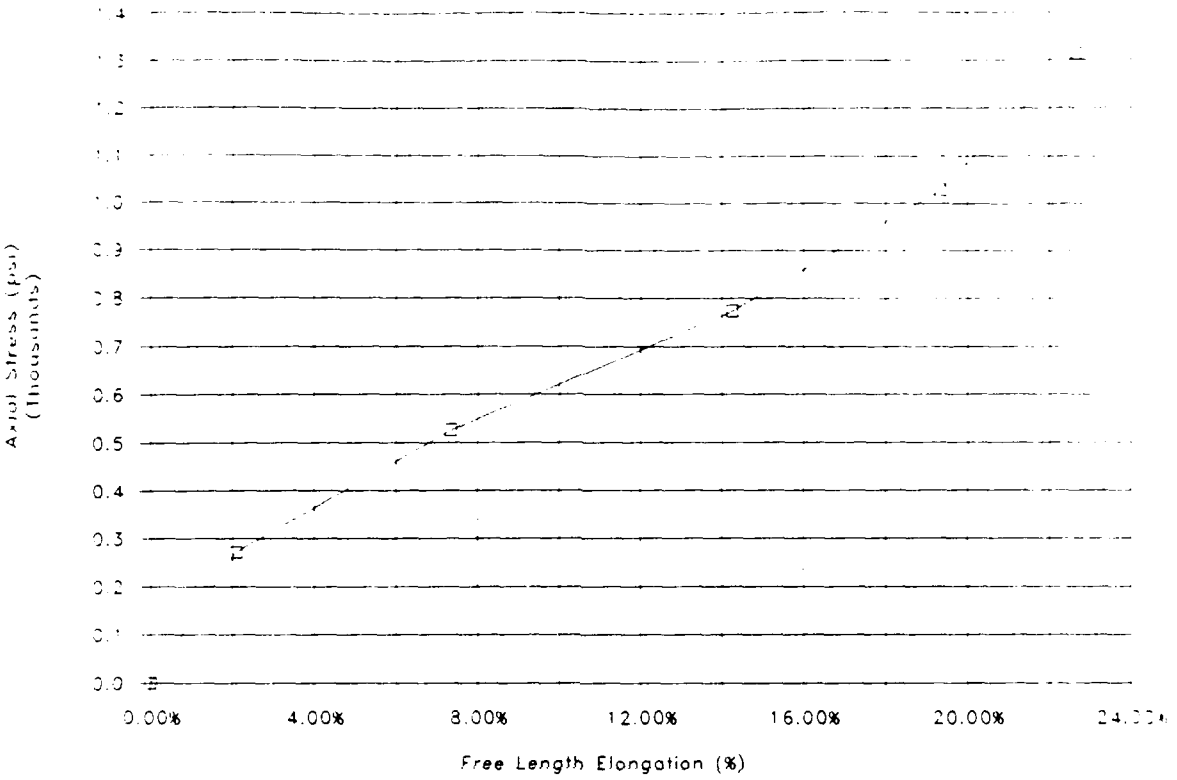
Load (lbs)	D1 (in)	D2 (in)	D3 (in)	Avg (in)	Avg X-Sect (sq-in)
0	7.78	7.72	7.78	7.76	19.02
5000	7.68	7.64	7.68	7.67	
10000	7.43	7.40	7.43	7.42	
15000	6.85	6.88	6.88	6.87	
20000	6.23	6.23	6.30	6.25	
25000	5.88	5.86	5.93	5.89	
(After 1hr)					
0	7.53	7.51	7.55	7.53	

Axial Strength Test

	Press (psi)	Load (lbs)
Expected Tensile Strength		80000
Actual Tensile Strength	839	52657

Axial Stress vs. Elongation

Hose 5UA12



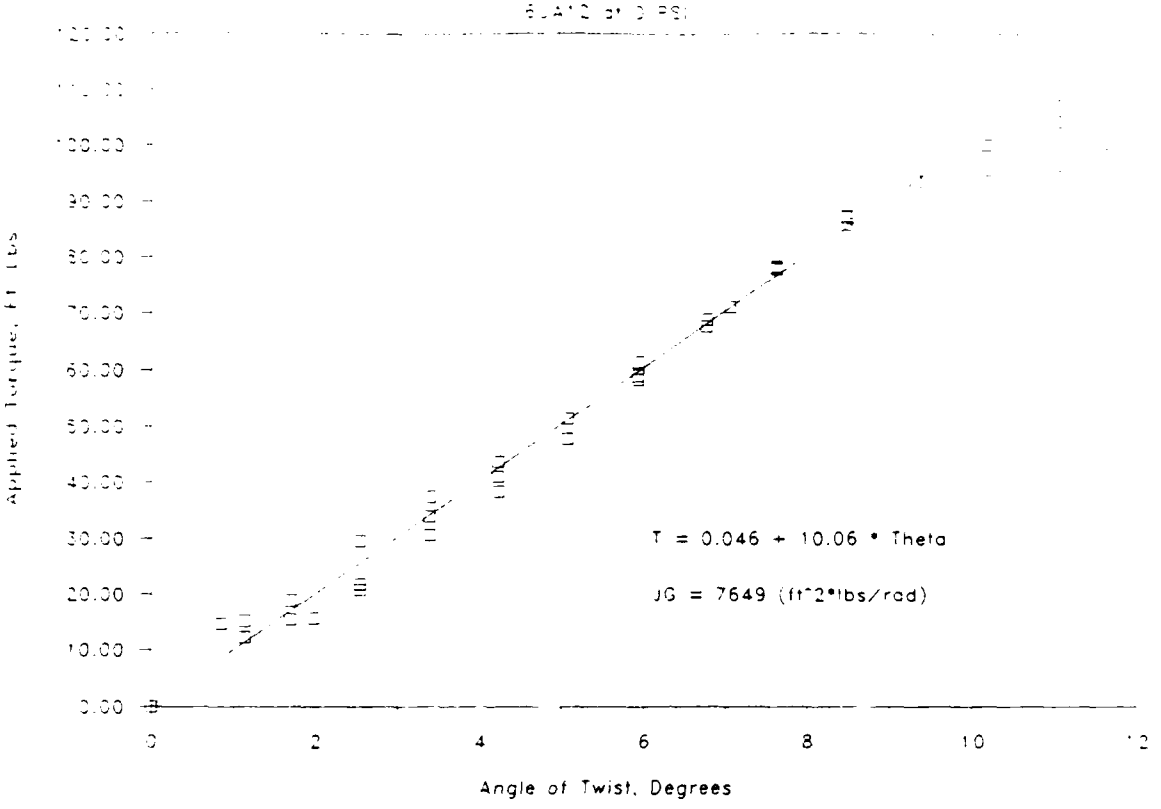
Vertical Torsional Stiffness Test

0 PSI Internal Pressure - RAW DATA:

6UA12
~~6UF12~~

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846			61	14.8		
4	1.129	63	15.3			51	12.3
6	1.693	78	18.9			64	15.5
7	1.975			65	15.7		
9	2.539	122	29.6	86	20.8	90	21.8
12	3.386	154	37.3	126	30.5	140	33.9
15	4.232	180	43.6	158	38.3	169	41.0
18	5.078	212	51.4	197	47.7	212	51.4
21	5.925	253	61.3	240	58.2	243	58.9
24	6.771	279	67.6	284	68.8		
25	7.053					293	71.0
27	7.618	321	77.8	323	78.3	322	78.1
30	8.464	359	87.0	354	85.8	360	87.3
33	9.310			386	93.6	397	96.2
34	9.592	389	94.3				
36	10.157	394	95.5	412	99.9		
39	11.003	397	96.2	429	104.0	449	108.9
41	11.567	413	100.1				
42	11.850			446	108.1	471	114.2

Torsional Stiffness Test

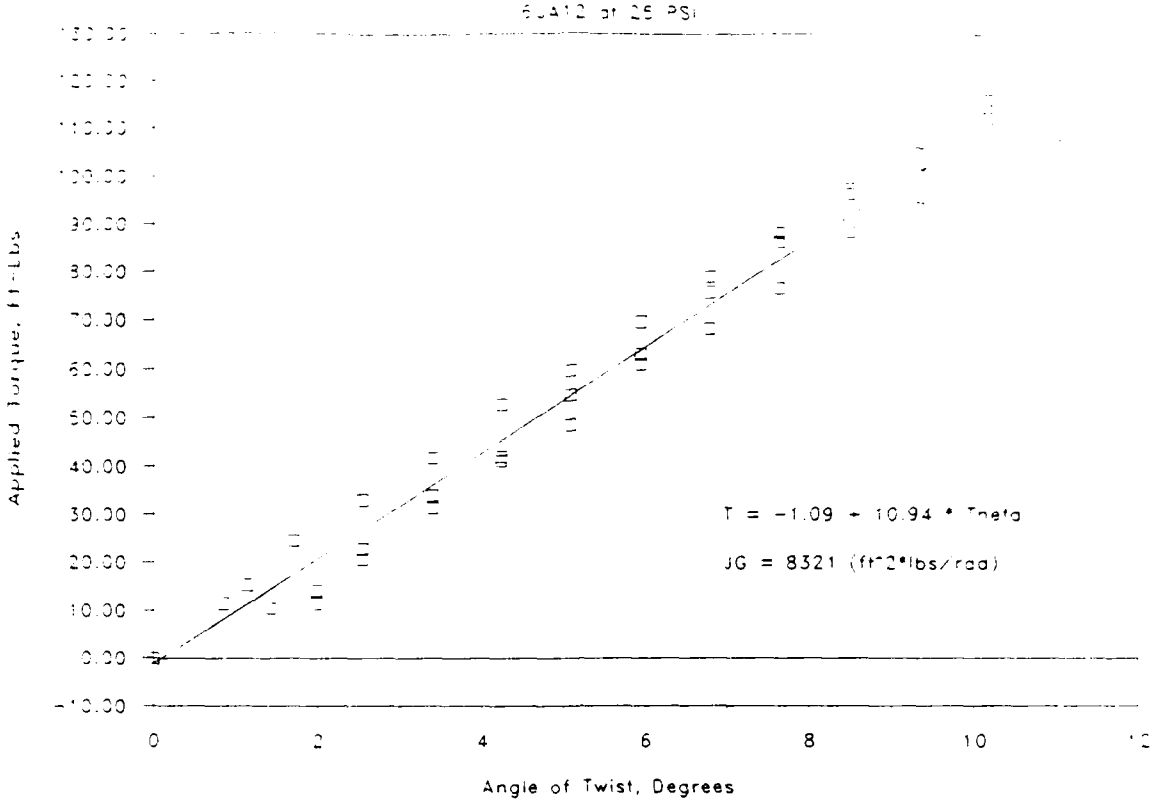


25 PSI Internal Pressure - RAW DATA

Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
3	0.846					47	11.4
4	1.129			63	15.3		
5	1.411	43	10.4				
6	1.693			101	24.5		
7	1.975	47	11.4			58	14.0
9	2.539	85	20.6	136	33.0	94	22.8
12	3.386	129	31.3	172	41.7	140	33.9
15	4.232	169	41.0	217	52.6	173	41.9
18	5.078	200	48.5	246	59.6	225	54.5
21	5.925	251	60.8	287	69.6	260	63.0
24	6.771	281	68.1	325	78.8	312	75.6
27	7.618	315	76.4	363	88.0	355	86.1
30	8.464	364	88.2	397	96.2	411	99.6
33	9.310	385	93.3	424	102.8	442	107.2
36	10.157	414	100.4	463	112.3	479	116.1
39	11.003	448	108.6	486	117.8		
40	11.285					526	127.5
42	11.850	477	115.6	510	123.6	536	130.0
45	12.696	495	120.0				

Torsional Stiffness Test

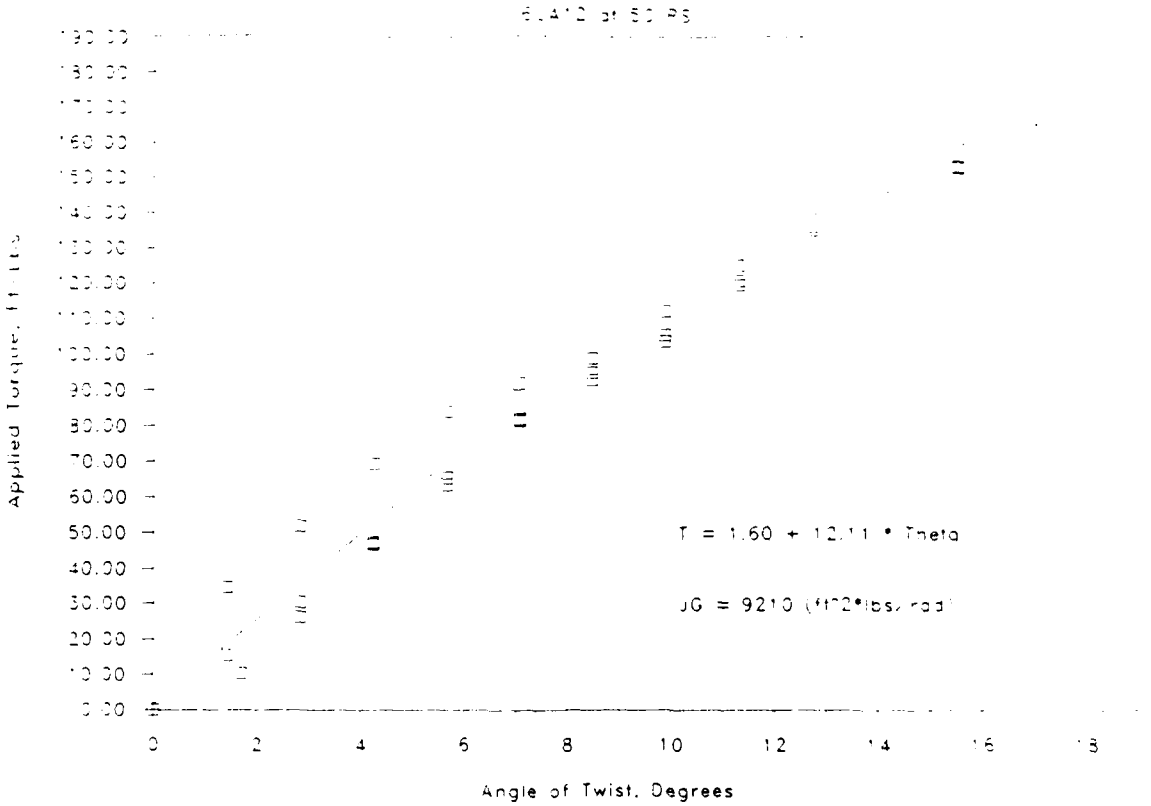
6.A12 at 25 PSI



50 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
5	1.411			64	15.5	143	34.7
6	1.693	43	10.4				
10	2.821	109	26.4	126	30.5	214	51.9
15	4.232	193	46.8	195	47.3	286	69.3
20	5.643	262	63.5	270	65.5	347	84.1
25	7.053	338	81.9	336	81.5	379	91.9
30	8.464	392	95.0	383	92.9	408	98.9
35	9.875	427	103.5	462	112.0	434	105.2
40	11.285	493	119.5	516	125.1	498	120.7
45	12.696	548	132.9	583	141.4	557	135.0
50	14.107	597	144.7	616	149.4		
55	15.517	631	153.0	665	161.2	632	153.2
60	16.928	677	164.1	717	173.8	687	166.6
65	18.339	726	176.0	759	184.0	735	178.2

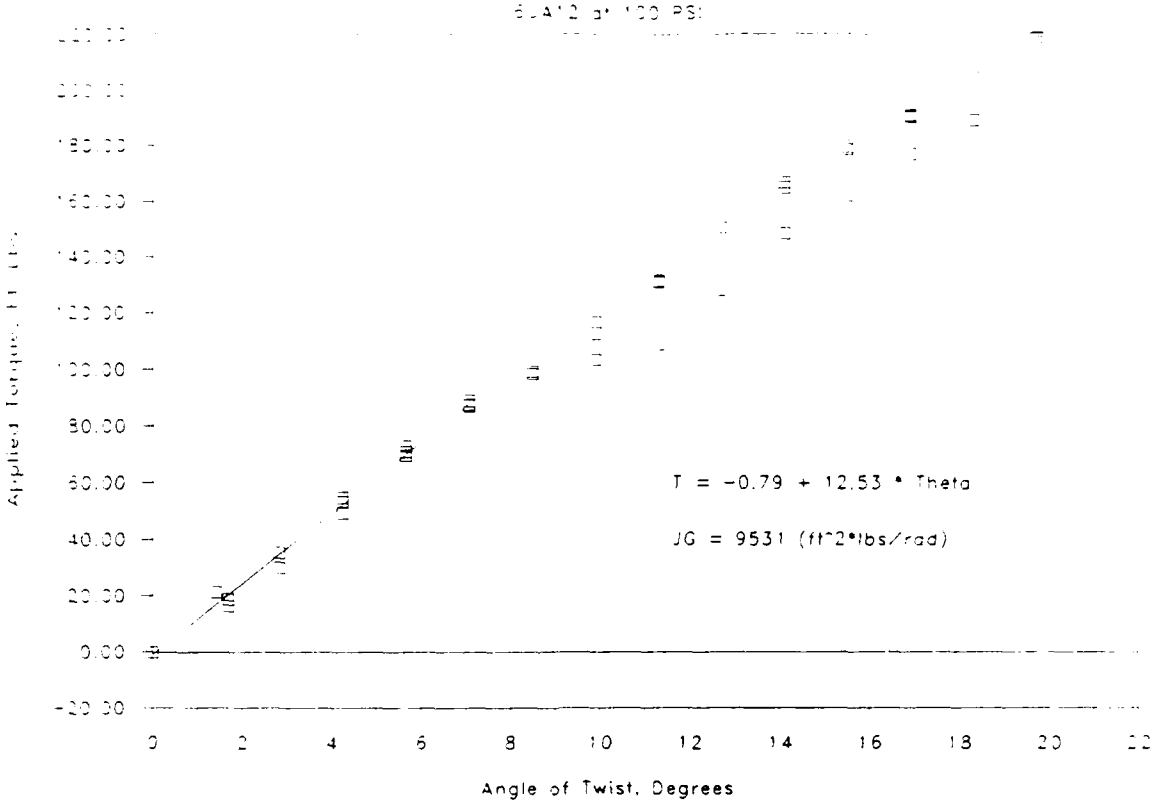
Torsional Stiffness Test



100 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
5	1.411			87	21.1		
6	1.693	78	18.9			68	16.5
10	2.821	123	29.8	145	35.1	145	35.1
15	4.232	203	49.2	225	54.5	219	53.1
20	5.643	286	69.3	300	72.7	292	70.8
25	7.053	358	86.8	365	88.5	359	87.0
30	8.464	404	97.9			408	98.9
35	9.875	426	103.3	465	112.7	482	116.9
40	11.285	449	108.9	541	131.2	543	131.7
45	12.696	529	128.3	622	150.8		
50	14.107	613	148.6	681	165.1	689	167.1
55	15.517	671	162.7	738	178.9	742	179.9
60	16.928	732	177.5	789	191.3	786	190.6
65	18.339	781	189.4	844	204.6	844	204.6
70	19.749	842	204.2	894	216.8	901	218.5
75	21.160	884	214.3				

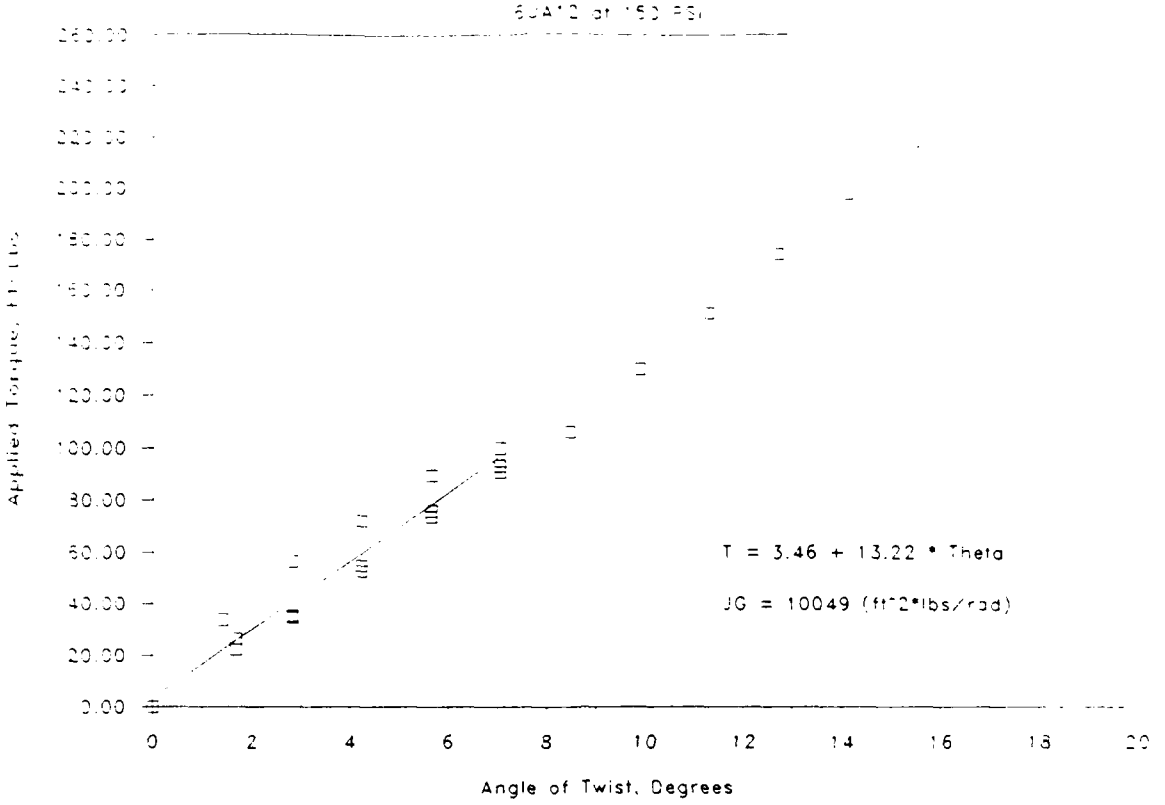
Torsional Stiffness Test



150 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
5	1.411			139	33.7		
6	1.693	109	26.4			91	22.0
10	2.821	145	35.1	232	56.2	143	34.7
15	4.232	226	54.8	297	72.0	217	52.6
20	5.643	312	75.6	368	89.2	303	73.5
25	7.053	373	90.4	411	99.6	383	92.9
30	8.464	409	99.2	440	106.7	436	105.7
35	9.875	488	118.3	494	119.8	536	130.0
40	11.285	570	138.2	575	139.4	625	151.5
45	12.696	632	153.2	644	156.1	721	174.8
50	14.107	722	175.1	702	170.2	819	198.6
55	15.517	802	194.5	785	190.3	904	219.2
60	16.928	881	213.6	884	214.3	946	229.4
65	18.339			943	228.7	988	239.6
70	19.749			986	239.1	1035	251.0

Torsional Stiffness Test



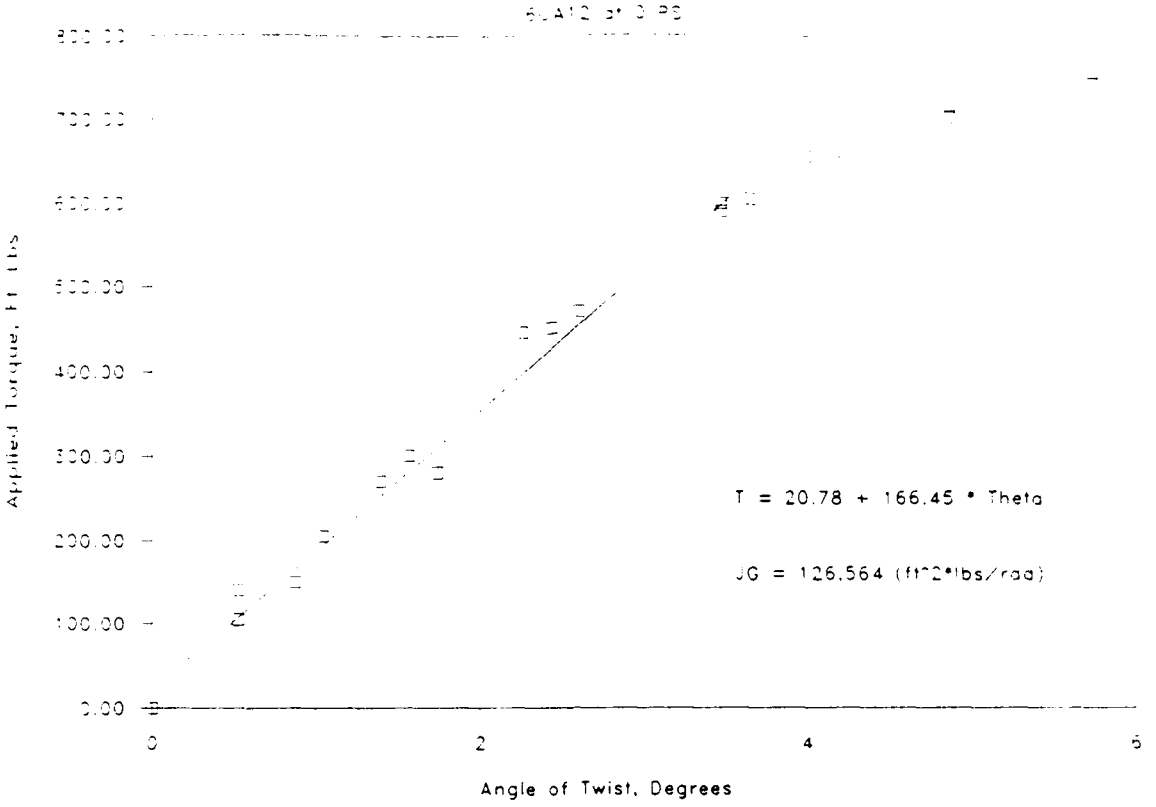
Horizontal Torsional Stiffness Test

0 PSI Internal Pressure - RAW DATA:

GUA:2
~~SUP12~~ DE7

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000		0		0		0
3	0.521				140		105
5	0.868		150				
6	1.041						205
8	1.389				270		
9	1.562						300
10	1.736		280				
13	2.257				445		
14	2.430						450
15	2.604		470				
20	3.472				590		600
21	3.645		605				
23	3.992				655		
24	4.166						660
25	4.339		655				
28	4.860				700		715
33	5.728				740		755
34	5.902		720				

Horizontal Torsional Stiffness Test

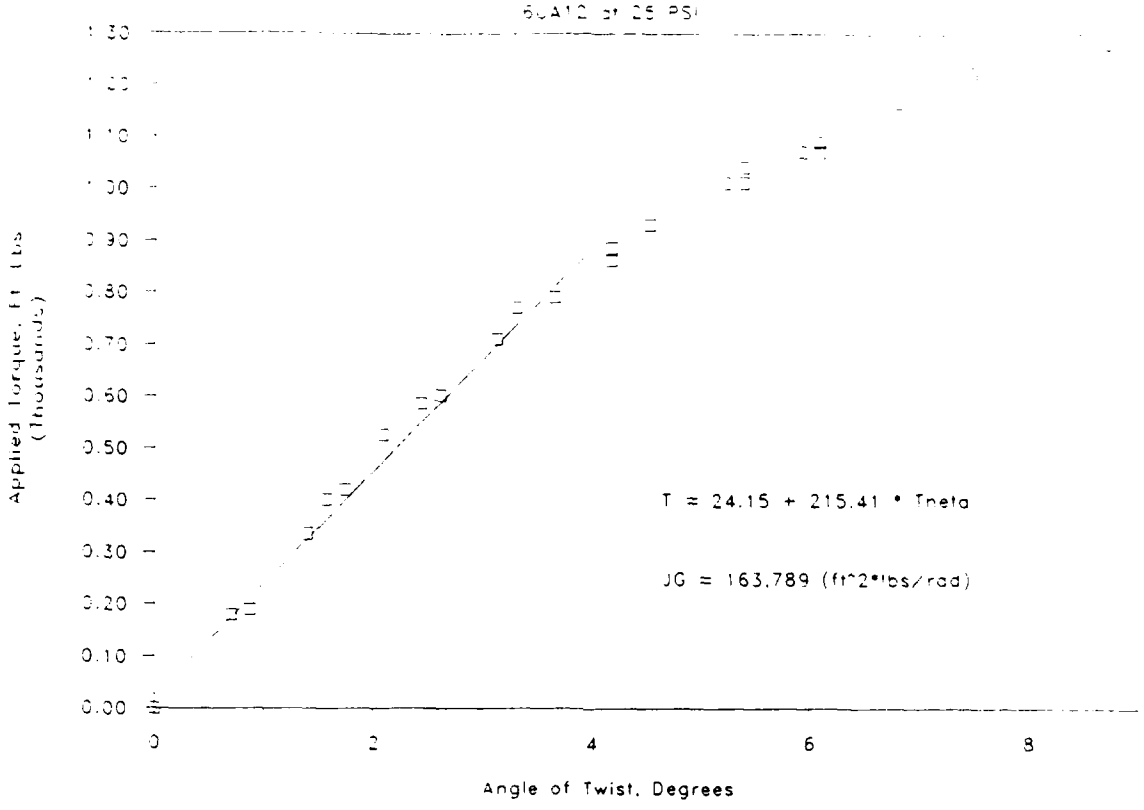


25 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000		0		0		0
4	0.694						180
5	0.868		190		190		
8	1.389		335				
9	1.562						400
10	1.736				420		
12	2.083		525				
14	2.430						585
15	2.604				600		
18	3.124		710				
19	3.298						770
21	3.645				790		
24	4.166		885		860		
26	4.513						930
30	5.207						1010
31	5.381		1040		1010		
34	5.902						1070
35	6.075		1090		1070		
39	6.770		1165				
41	7.117						1200
43	7.464		1225		1210		
46	7.985				1230		
50	8.679		1240				1280
51	8.852				1250		

Horizontal Torsional Stiffness Test

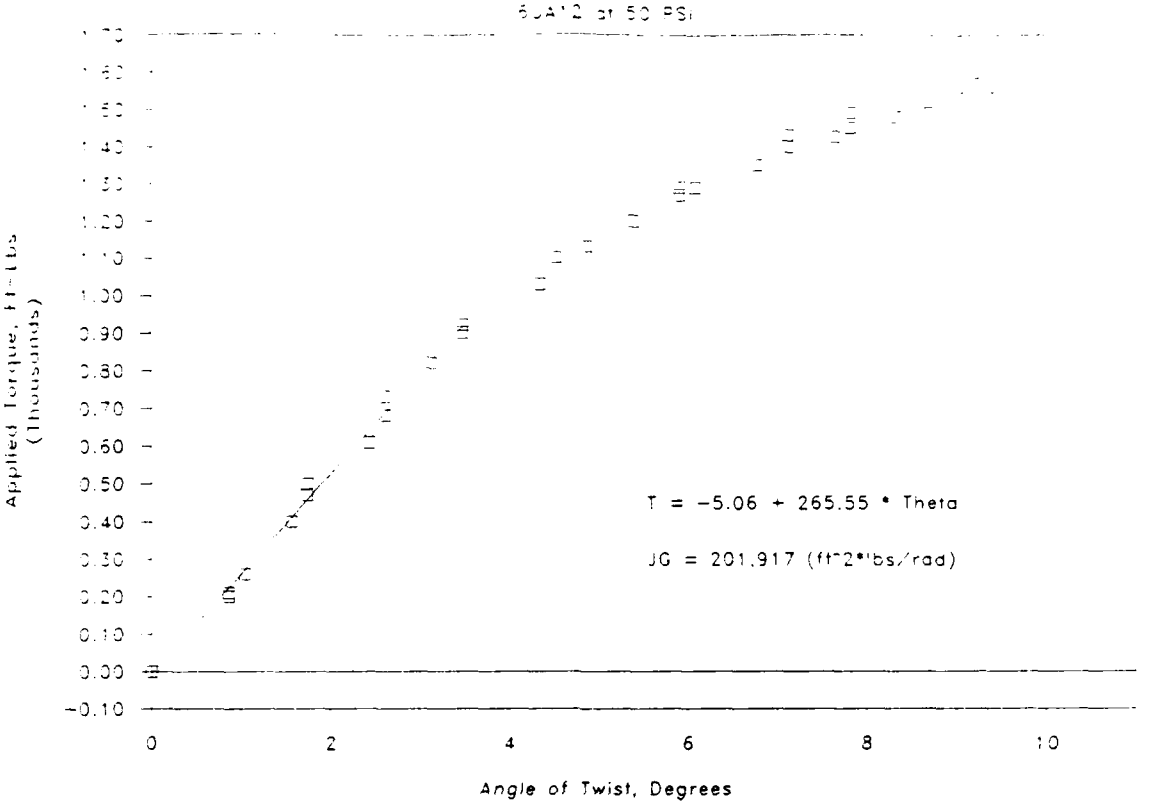
6LA12 at 25 PSI



50 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000		0		0		0
5	0.868				200		210
6	1.041		260				
9	1.562						400
10	1.736		500		470		
14	2.430						610
15	2.604		730		680		
18	3.124						820
20	3.472		920		900		
25	4.339						1030
26	4.513				1100		
28	4.860		1130				
31	5.381						1200
34	5.902		1290		1270		
35	6.075						1290
39	6.770						1350
41	7.117		1430		1400		
44	7.637						1425
45	7.811		1490		1450		
48	8.332						1480
50	8.679				1520		
52	9.026						1560
53	9.200		1600				
54	9.373				1560		
60	10.415		1640				

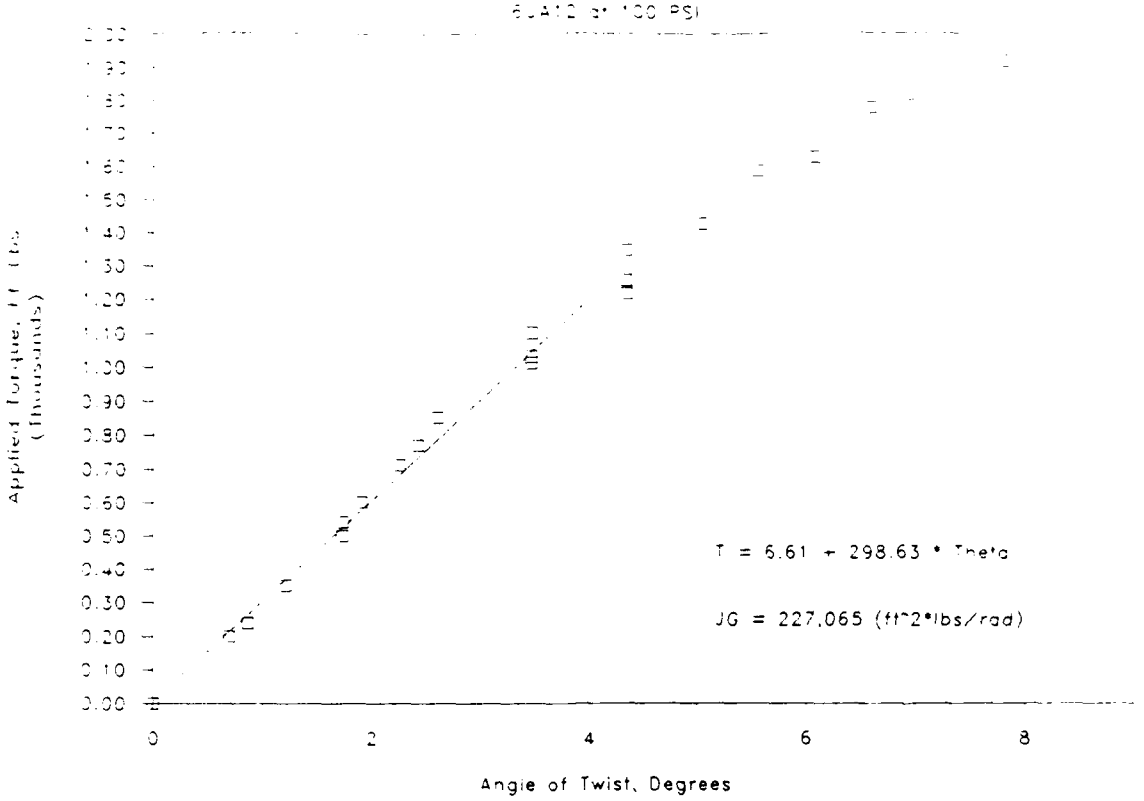
Horizontal Torsional Stiffness Test



100 PSI Internal Pressure - RAW DATA

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000		0		0		0
4	0.694						200
5	0.868		240				
7	1.215				350		
10	1.736		540		500		
11	1.909						600
13	2.257				710		
14	2.430		770				
15	2.604						850
20	3.472		1010		1030		1100
25	4.339		1260		1220		1350
29	5.034				1430		
31	5.381		1510				
32	5.554						1590
35	6.075				1630		
37	6.422		1710				
38	6.596						1780
40	6.943		1790		1820		
44	7.637		1810				
45	7.811				1920		
51	8.852		1930				

Horizontal Torsional Stiffness Test



Crush Test

I.D. = 6 "

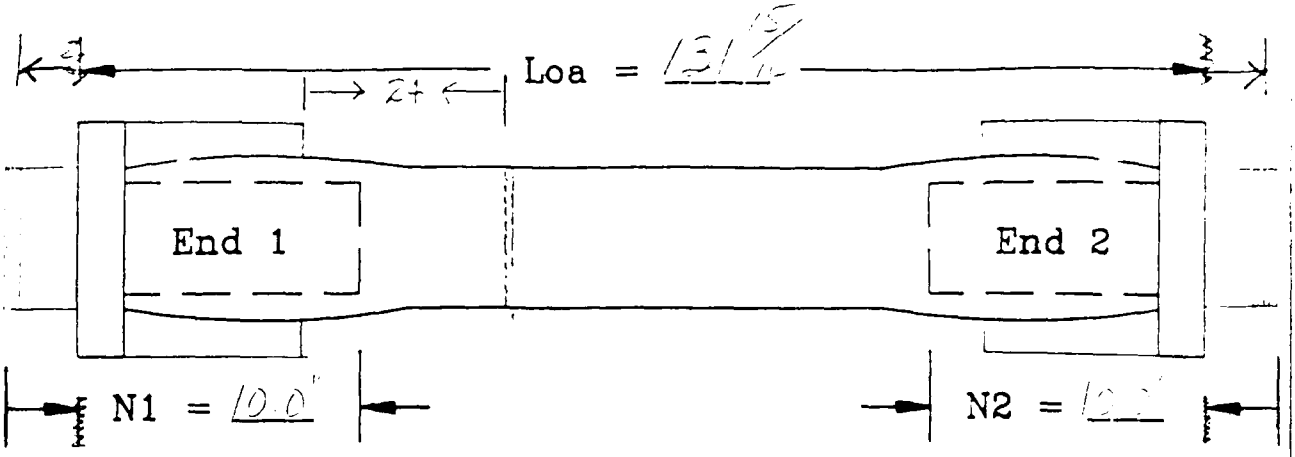
Crush (%)	Deflect (in)	Req'd Load (lbs)	Set (in)	I.D. Recovery (%)
10%	0.6	368	0.00	100.00%
20%	1.2	587	0.08	98.67%
30%	1.8	688	0.13	97.83%
40%	2.4	782	0.19	96.83%
50%	3.0	872	0.25	95.83%
60%	3.6	971	0.30	95.00%
70%	4.2	1090	0.39	93.50%
80%	4.8	1248	0.40	93.33%
90%	5.4	1496	0.46	92.33%
100%	6.0	1600	0.49	91.83%
After 5 min. -			0.39	93.50%

Data Package for Uniroyal Sample 6UF10A

Acceptance Test Data Sheet

Data Sheet No. [illegible]

Hose I.D. Code [illegible]



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	7.484"
48.0"	7.647"
72.0"	7.504
96.0"	7.500"

Signature [illegible]

Date [illegible]

SOUTHWEST RESEARCH INSTITUTE
DEPARTMENT OF STRUCTURAL AND MECHANICAL SYSTEMS
COMPUTATION SHEET

SHEET NO. 2 OF 4

PROJECT NO. 17-7158 SPONSOR:
SUBJECT: VACUUM TEST OF EPIZB, 6UF30, & 6UA1ZB
BY [redacted] DATE: 10/25/19 CHECKED BY: DATE CHECKED 19

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

SUPERVISING TEST ENGINEER: J.P. HARRELL

NOTE: 6UF10A BURST DURING THE KEROSENE TEST AND WAS THEREFORE NOT INCLUDED IN THE VACUUM TEST

EPIZB

- HELD 15" VACUUM (MIN)
- NO VISIBLE WEEPING, BLISTERING, DELAMINATION OR COLLAPSE
- HOSE PASSED BY J.P. HARRELL

6UA1ZB

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. HARRELL

~~6UF3E~~ 6UA30

- HELD 15" VACUUM (MIN)
- NO ADVERSE INDICATIONS
- HOSE PASSED BY J.P. HARRELL

SOUTHWEST RESEARCH INSTITUTE
San Antonio, Texas 78284

Project 10-7958-237

KEROSENE TEST — HI – 8UA12B & ~~6UF30~~ 6UA30
LOW – 8P12B & 6UF10A

TIME	HI	LOW	
2230	1066	610	
2245	1065	604	
23:00	1061	599	6UF10A Blew Apart of End "B"
23:17	1070	683	8P12B WASN't often pressurized @ 1st HR –
23:30	1058	630	" over pressurized, just letting press. settle
2345	1065	602	
2400	1064	599	
~~00~~15	1061	595	
~~00~~30	1058	594	
~~00~~45	1061	631	
1:00	1052	614	
1:15	1061	601	
1:30	1068	608	
1:45	1061	598	
2:00	1066	607	
2:15	1060	597	
2:30	1071	607	
2:45	1066	598	
3:00	1062	592	
3:15	1064	609	
3:30	1057	601	
3:45	1065	604	
4:00	1061	597	
4:15	1070	605	
4:30	534	598	
04:45	537	607	
05:00	537	601	
0515	536	609	
0530	535	604	(304) pressure reduced in 8P12B to 300 ps
0545	533	307	
0600	531	309	
0615	530	304	
0630	534	304	
0645	533	304	
0700	532	303	

Date: 10/27/88 Signature: D.W. Johnson / Joe Canellis

(SwR 17) Rev 6/75

KEROSENE TEST

TIME	HI	LOW	
0715	531	302	
0730	529	301	
0745	535	300	
0800	532	303	
0815	529	302	
0835	538	301	
0900	539	302	
0915	540	302	
0930	541	302	
1000	535	307	
1015	538	309	
1030	541	312	- BLED BOTH DOWN
1045	532	305	
1100	537	309	
11.15	544	315	- Bled Both Down.
11:16	531	302	
11:30	537	309	
11:45	543	314	- Bled Both Down.
11:46	529	302	
12:02	536	312	
1212	529	302	Bled Both Down
12:30	543	316	Bled Both Down.
12:31	529	299	
12:55	556	329	Bled Both Down
12:57	528	300	
13:15	542	322	Bled off Both.
13:16	529	302	
1337	550	343	Bled both
1338	529	303	
1400	550	327	Bled both
1401	528	302	
1420	550	327	
1430	533	306	
1440	500	316	
1500	470	312	End Test

Date: 10/28/98

Signature: D.W. Johnson

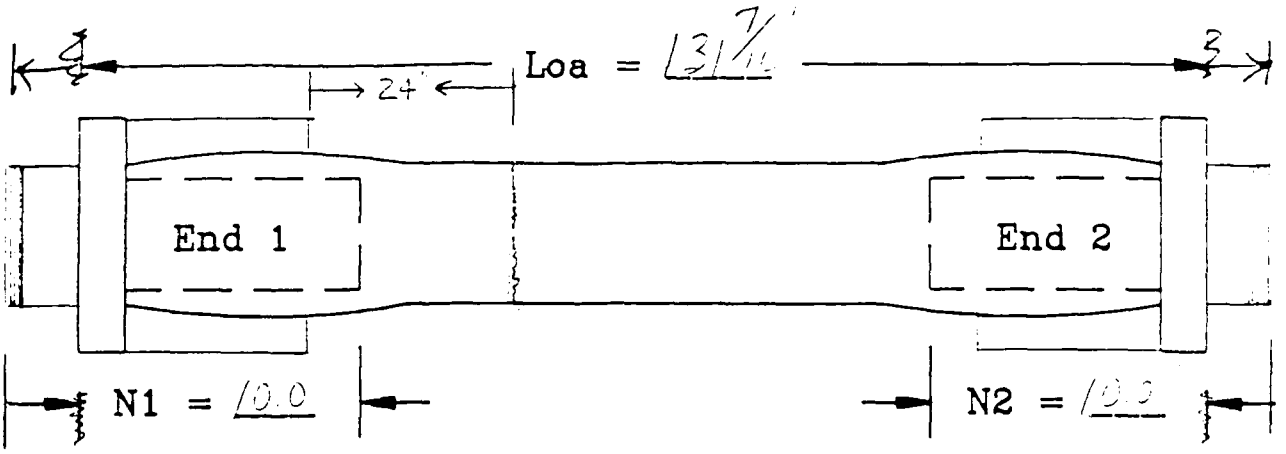
SwR 171 Rev 6/85

Data Package for Uniroyal Sample 6UF10B

Acceptance Test Data Sheet

Data Sheet No. 003

Hose I.D. Code



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	7.474"
48.0"	7.430"
72.0"	7.512"
96.0"	7.484

Signature

Date

Test Results Worksheet
Hose 6UF10B

Axial Load vs. Elongation Test

Lo = 133.25 "
Nipple = 10.00 "

Load (lbs)	Load Cell (lbs)	Hyd. Press. (psi)	Actual Load (lbs)	Actual Load (lbs)	Eng. Stress (psi)	Measured Length (inches)	Free Length (inches)	F.L. Elongatio (%)
0	0	0	0	0	0.00	133.25	113.25	0.00%
2000	1637	42	1389	1872	118.80	133.38	113.38	0.11%
5000	4912	91	4318	5002	317.41	133.94	113.94	0.61%
10000	10048	169	8955	9983	633.43	135.06	115.06	1.60%
15000	15275	251	13780	15216	965.48	137.81	117.81	4.03%
20000	20121	328	18376	20127	1277.11	140.44	120.44	6.35%
25000	25029	407	23160	25164	1596.67	142.56	122.56	8.22%
0	338	0	0	0	0.00	135.38	115.38	1.88%

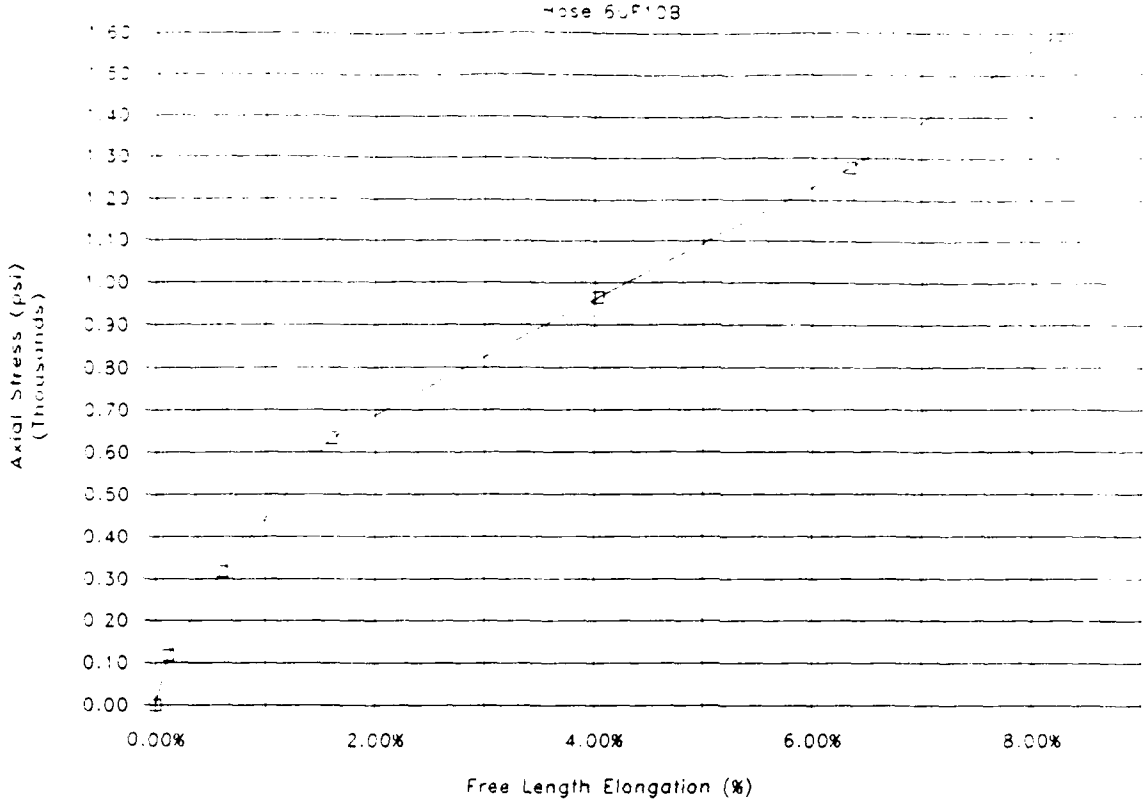
Load (lbs)	D1 (in)	D2 (in)	D3 (in)	D4 (in)	Avg (in)	Avg X-Sect (sq-in)
0	7.46	7.52	7.50	7.48	7.49	15.76
2000	---	---	---	---	---	
5000	7.45	7.50	7.47	7.46	7.47	
10000	7.41	7.45	7.42	7.42	7.43	
15000	7.33	7.36	7.34	7.32	7.34	
20000	7.24	7.26	7.24	7.23	7.24	
25000	7.17	7.18	7.16	7.15	7.17	
(After 1hr)						
0	7.40	7.44	7.42	7.41	7.42	

Axial Strength Test

	Hyd Press (psi)	Axial Load (lbs)
Expected Tensile Strength =		55,000
Actual Tensile Strength =	870	54,627

Axial Load vs. Elongation Test

Hose 6JF10B



Crush Test — 6UF10B

I.D. = 6.00 "

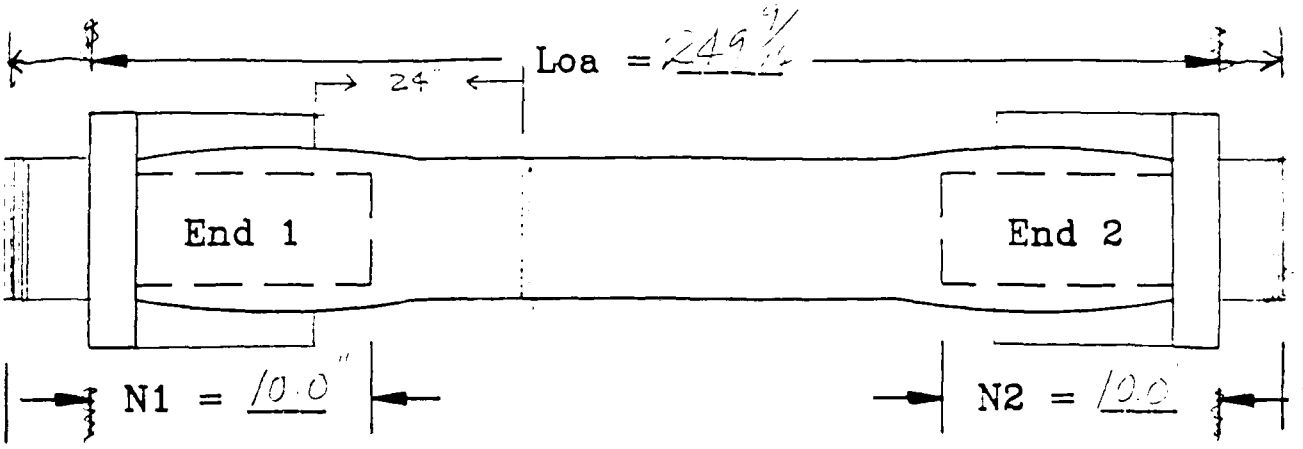
Crush (%)	Deflect (in)	Req'd Load (lbs)	Set (in)	I.D. Recovery (%)
10%	0.60	216	0.00	100.00%
20%	1.20	348	0.01	99.83%
30%	1.80	424	0.07	98.83%
40%	2.40	488	0.10	98.33%
50%	3.00	552	0.13	97.92%
60%	3.60	614	0.19	96.83%
70%	4.20	686	0.20	96.67%
80%	4.80	781	0.25	95.83%
90%	5.40	925	0.29	95.17%
100%	6.00	1016	0.30	95.00%
After 5 min.	-		0.20	96.67%

Data Package for Uniroyal Sample 6UF20

Acceptance Test Data Sheet

Data Sheet No. 001

Hose I.D. Code [illegible]



Free Length = Loa − (N1 + N2) = _____

Dist from End 1	Outside Diameter
24.0"	7.515"
48.0"	7.444
72.0"	7.480"
96.0"	7.500
120.0"	7.510
144.0"	7.493"
168.0"	7.475"
192.0"	7.447
216.0"	7.518

Signature [illegible]

Date [illegible]

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
6UA3C ~~6UF30~~	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
6UA3C ~~6UF30~~	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
6UA3C ~~6UF30~~	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

Kink Test

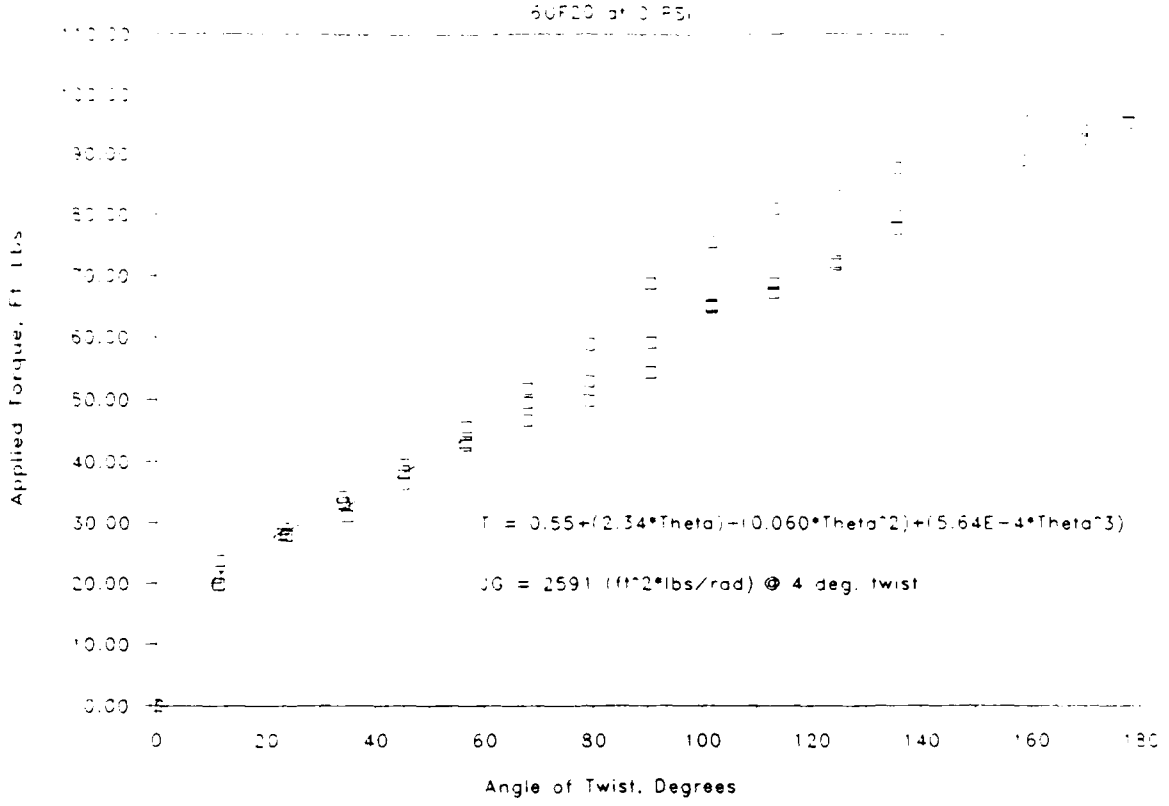
Intrnl Press (psi)	X (in)	Y (in)	R (in)	Req'd Pull (lbs)
0	174.00	68.25	76.00	30
25	69.00	99.50	12.00	---
50	n/a	n/a	11.00	---
100	n/a	n/a	2.5	---

Torsional Stiffness Test

0 PSI Internal Pressure - RAW DATA: 6UF20

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
38	10.721			87	21.1		
40	11.285	98	23.7			82	19.9
80	22.571					116	28.1
82	23.135			120	29.1		
84	23.699	115	27.9				
120	33.856			141	34.2		
121	34.138					137	33.2
123	34.702	128	31.0				
160	45.141	150	36.4	163	39.5	158	38.3
200	56.426	188	45.6	176	42.7	178	43.1
240	67.712	213	51.6	192	46.5	204	49.4
280	78.997	243	58.9	205	49.7	218	52.8
320	90.282	284	68.8	224	54.3	244	59.1
360	101.567	312	75.6	269	65.2	268	65.0
400	112.853	335	81.2	278	67.4	284	68.8
440	124.138	351	85.1	297	72.0	299	72.5
480	135.423	363	88.0	322	78.1	330	80.0
520	146.708	378	91.6	352	85.3	352	85.3
560	157.994			368	89.2	368	89.2
564	159.122	402	97.5				
600	169.279	421	102.1	388	94.1	382	92.6
630	177.743	448	108.6	400	97.0	393	95.3

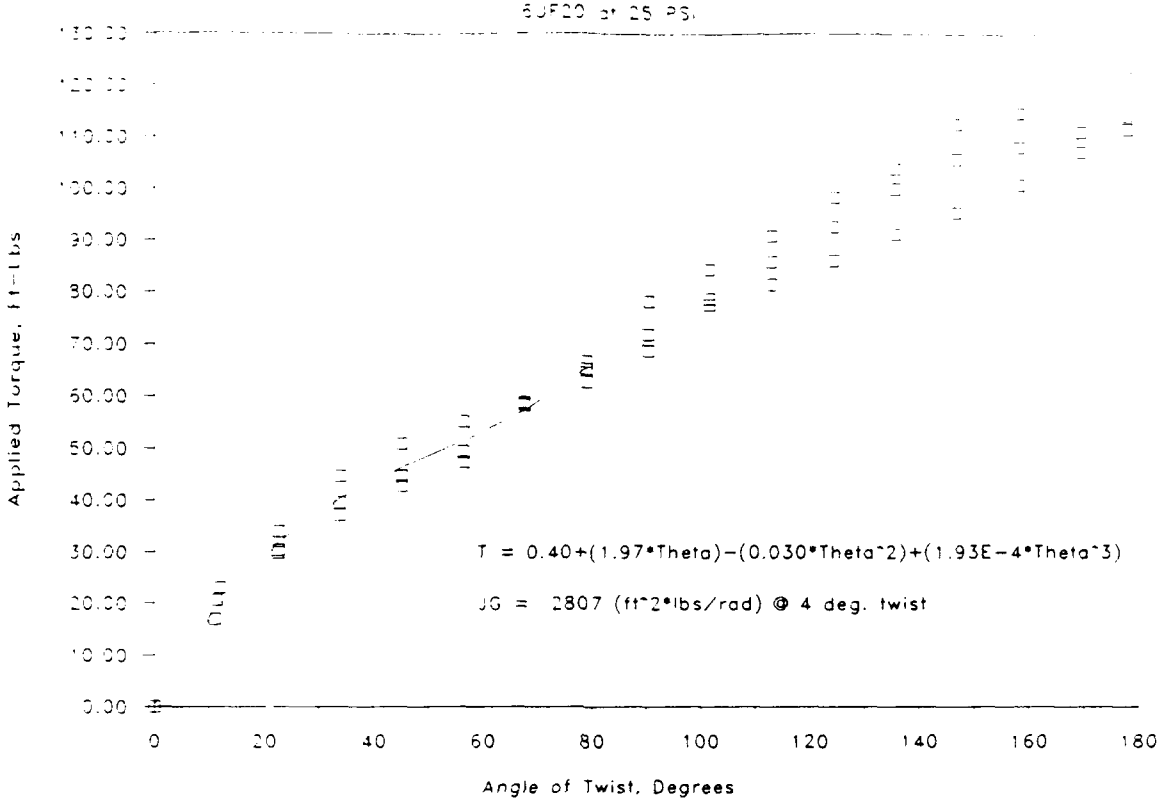
Torsional Stiffness Test



25 PSI Internal Pressure - RAW DATA 6UF20

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
39	11.003					70	17.0
40	11.285	85	20.6				
42	11.850			95	23.0		
80	22.571	125	30.3	140	33.9	123	29.8
120	33.856	153	37.1	184	44.6	163	39.5
160	45.141	176	42.7	209	50.7	184	44.6
200	56.426	195	47.3	227	55.0	203	49.2
240	67.712	240	58.2	242	58.7	241	58.4
280	78.997	274	66.4	258	62.5	268	65.0
320	90.282	322	78.1	296	71.8	283	68.6
360	101.567	347	84.1	324	78.5	319	77.3
400	112.853	374	90.7	335	81.2	353	85.6
440	124.138	405	98.2	354	85.8	381	92.4
480	135.423	428	103.8	376	91.2	412	99.9
520	146.708	464	112.5	393	95.3	436	105.7
560	157.994	472	114.4	415	100.6	445	107.9
600	169.279	496	120.3	441	106.9	457	110.8
630	177.743	509	123.4	459	111.3	470	113.9

Torsional Stiffness Test

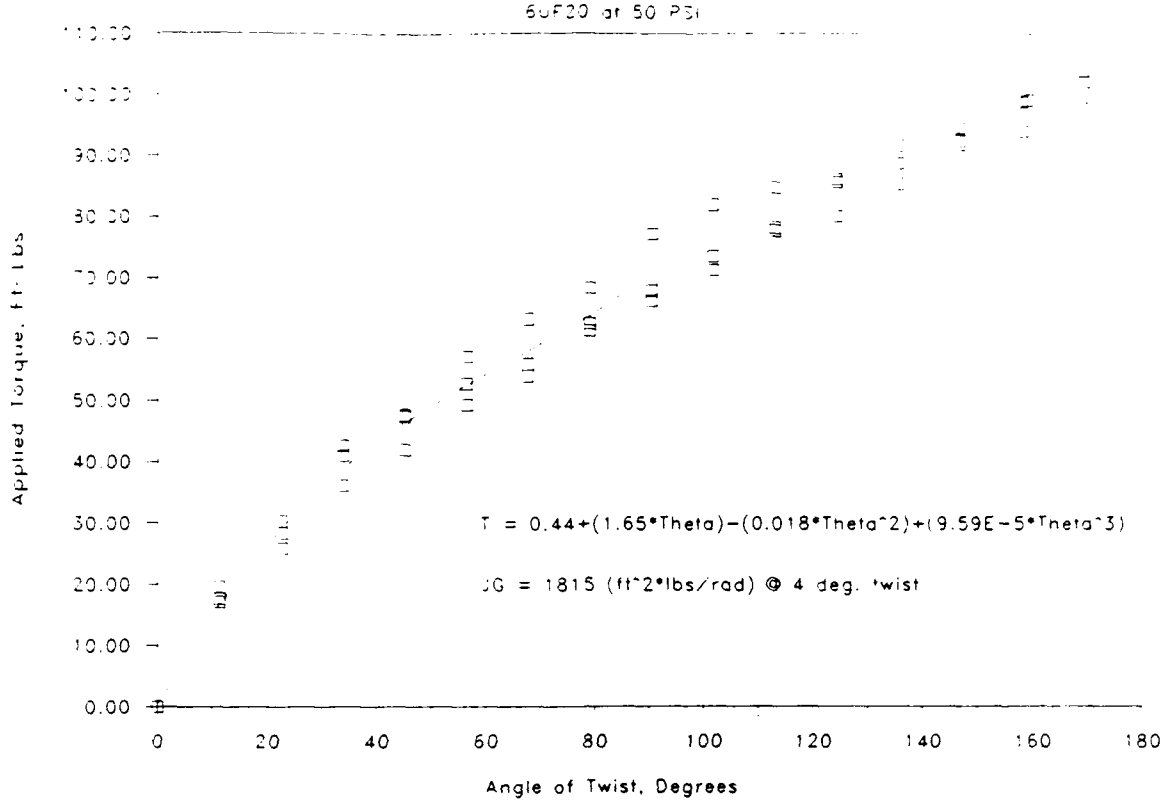


50 PSI Internal Pressure - RAW DATA 6UF20

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
40	11.285	73	17.7	71	17.2	81	19.6
80	22.571	117	28.3	107	25.9	125	30.3
120	33.856	169	41.0	149	36.1	176	42.7
160	45.141	196	47.5	173	41.9	195	47.3
200	56.426	235	57.0	203	49.2	217	52.6
240	67.712	260	63.0	222	53.8	230	55.8
280	78.997	281	68.1	252	61.1	257	62.3
320	90.282	317	76.8	279	67.6	272	65.9
360	101.567	337	81.7	293	71.0	302	73.2
400	112.853	349	84.6	320	77.6	322	78.1
440	124.138	355	86.1	330	80.0	353	85.6
480	135.423	366	88.7	352	85.3	378	91.6
520	146.708	381	92.4	371	89.9	390	94.6
560	157.994			387	93.8	407	98.7
564	159.122	408	98.9				
600	169.279	428	103.8	402	97.5	420	101.8
610	172.100					423	102.6
630	177.743	435	105.5	418	101.3		

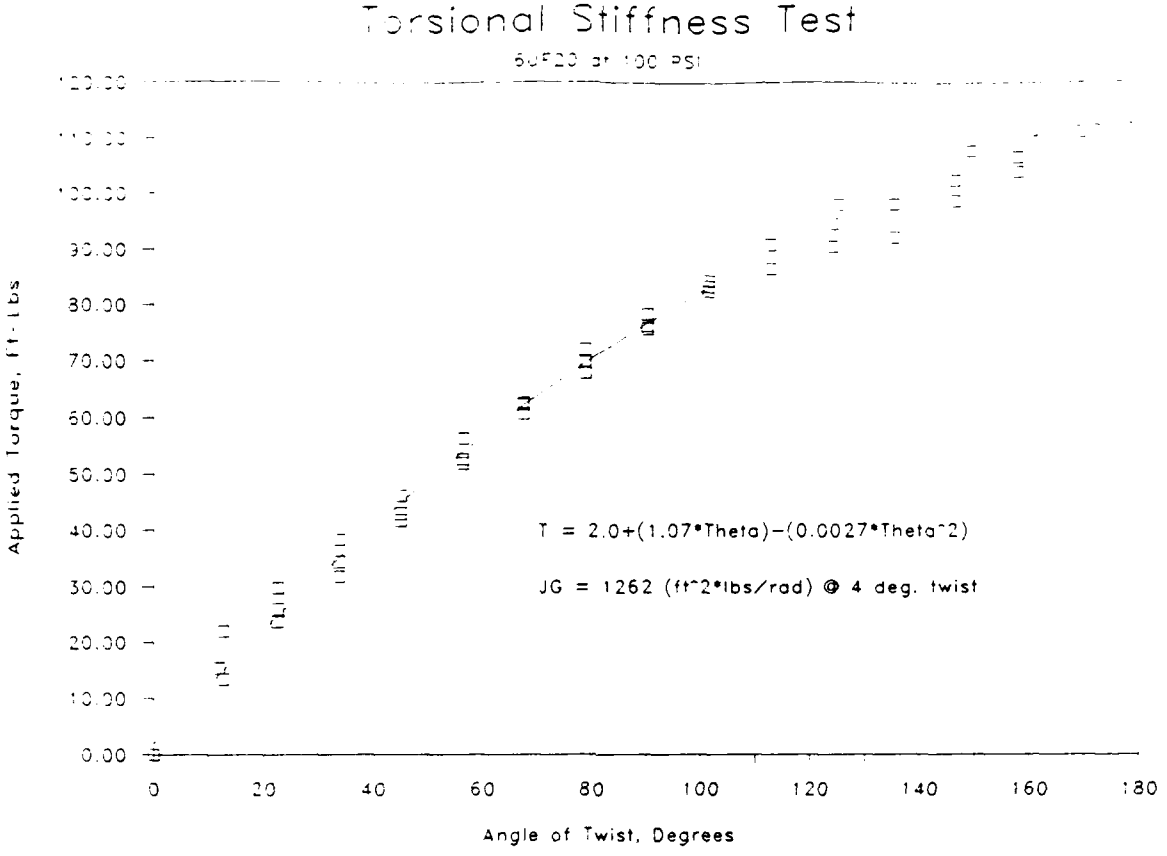
Torsional Stiffness Test

6UF20 at 50 PSI



100 PSI Internal Pressure - RAW DATA 6UF20

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
42	11.850	64	15.5				
45	12.696			56	13.6	91	22.0
80	22.571	107	25.9	98	23.7	123	29.8
120	33.856	142	34.4	131	31.7	158	38.3
160	45.141	172	41.7	177	42.9	190	46.1
200	56.426	214	51.9	232	56.2	217	52.6
240	67.712	250	60.6	258	62.5	257	62.3
280	78.997	297	72.0	280	67.9	288	69.8
320	90.282	323	78.3	312	75.6	314	76.1
360	101.567	347	84.1	339	82.2	343	83.2
400	112.853	374	90.7	356	86.3	374	90.7
440	124.138	390	94.6	373	90.4		
444	125.266					404	97.9
480	135.423	405	98.2	380	92.1		
520	146.708	422	102.3	407	98.7		
530	149.530					444	107.6
560	157.994	439	106.4	428	103.8		
570	160.815					459	111.3
580	163.636					466	113.0
600	169.279	458	111.0				
610	172.100			467	113.2		
630	177.743	468	113.5				

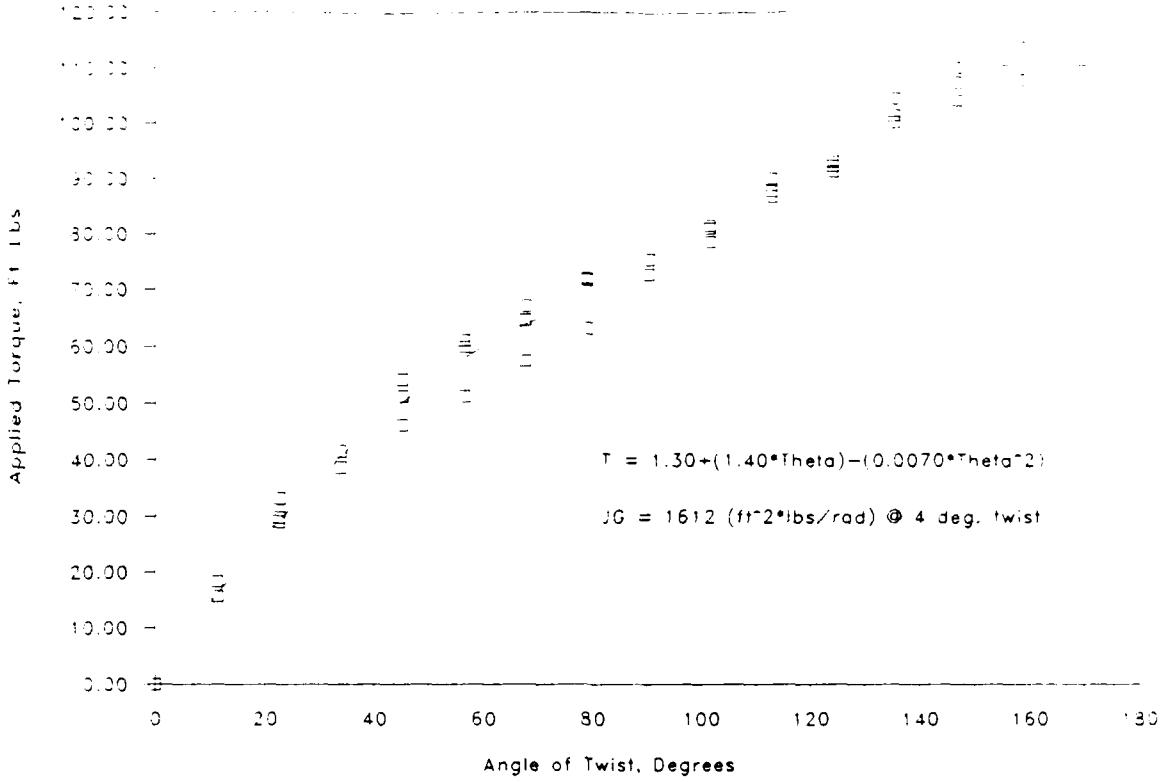

Torsional Stiffness Test
60F20 at 100 PSI
Applied Torque, ft-lbs
120.00
110.00
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
20
40
60
80
100
120
140
160
180
Angle of Twist, Degrees
T = 2.0+(1.07*Theta)-(0.0027*Theta^2)
JG = 1262 (ft^2*lbs/rad) @ 4 deg. twist

150 PSI Internal Pressure - RAW DATA 6UF20

		Run 1		Run 2		Run 3	
Rotation (MM)	Rotation (Deg)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)	Hyd Press (PSI)	Torque (Ft-Lb)
0	0.000	0	0	0	0	0	0
40	11.285	65	15.7	76	18.4	76	18.4
80	22.571	120	29.1	137	33.2	123	29.8
120	33.856	159	38.5	171	41.4	159	38.5
160	45.141	223	54.1	190	46.1	211	51.1
200	56.426	252	61.1	211	51.1	247	59.9
240	67.712	277	67.1	237	57.4	267	64.7
280	78.997	297	72.0	261	63.3	298	72.2
320	90.282	312	75.6	301	73.0	312	75.6
360	101.567	337	81.7	335	81.2	325	78.8
400	112.853	372	90.2	363	88.0	359	87.0
440	124.138	385	93.3	378	91.6	382	92.6
480	135.423	415	100.6	432	104.7	420	101.8
520	146.708	431	104.5	455	110.3	444	107.6
550	155.172					460	111.5
560	157.994	445	107.9	477	115.6		
570	160.815			486	117.8	466	113.0
600	169.279	459	111.3				
630	177.743	477	115.6				

Torsional Stiffness Test

60F20 at 150 PSI

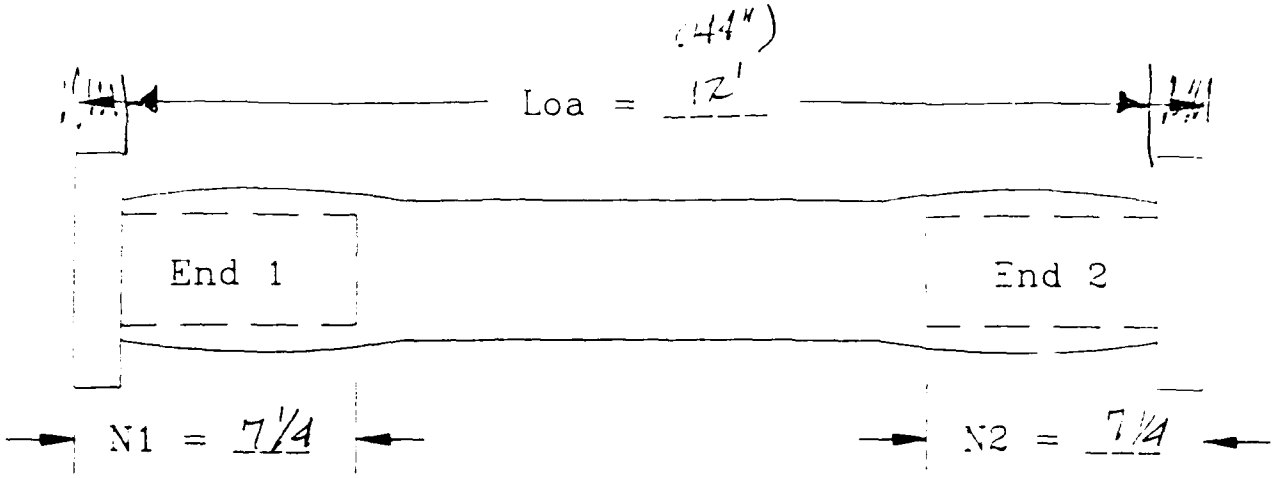


Data Package for Angus Sample 6AW12

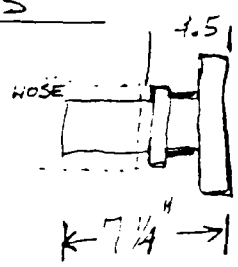
DIMENSION
~~Acceptance Test~~ Data Sheet

Data Sheet No [illegible]

Hose I.D. Code [illegible]



Free Length = Loa − (~~N1 + N2~~) = 138.5"
(2 * 2.75)



Nipple on fig.

Dist from End 1	Outside Diameter

Signature [illegible]

Date [illegible]

[illegible] completed & inspected

Kerosene test on 6AW12 - NO ADVERSE INDICATIONS

-No pressure due to leaks —

D.W. Johnson 11/30/88
Joe Carellis

KEROSENE TEST ON 6AP12 - NO ADVERSE INDICATIONS

-No pressure due to leaks at coupling

completed & inspector on 11/30/88

D.W. Johnson 11/30/88

Test Results Worksheet
Hose 6AW12

Axial Load vs. Elongation Test

Lo = 154.00 "
Nipple = 7.25 "

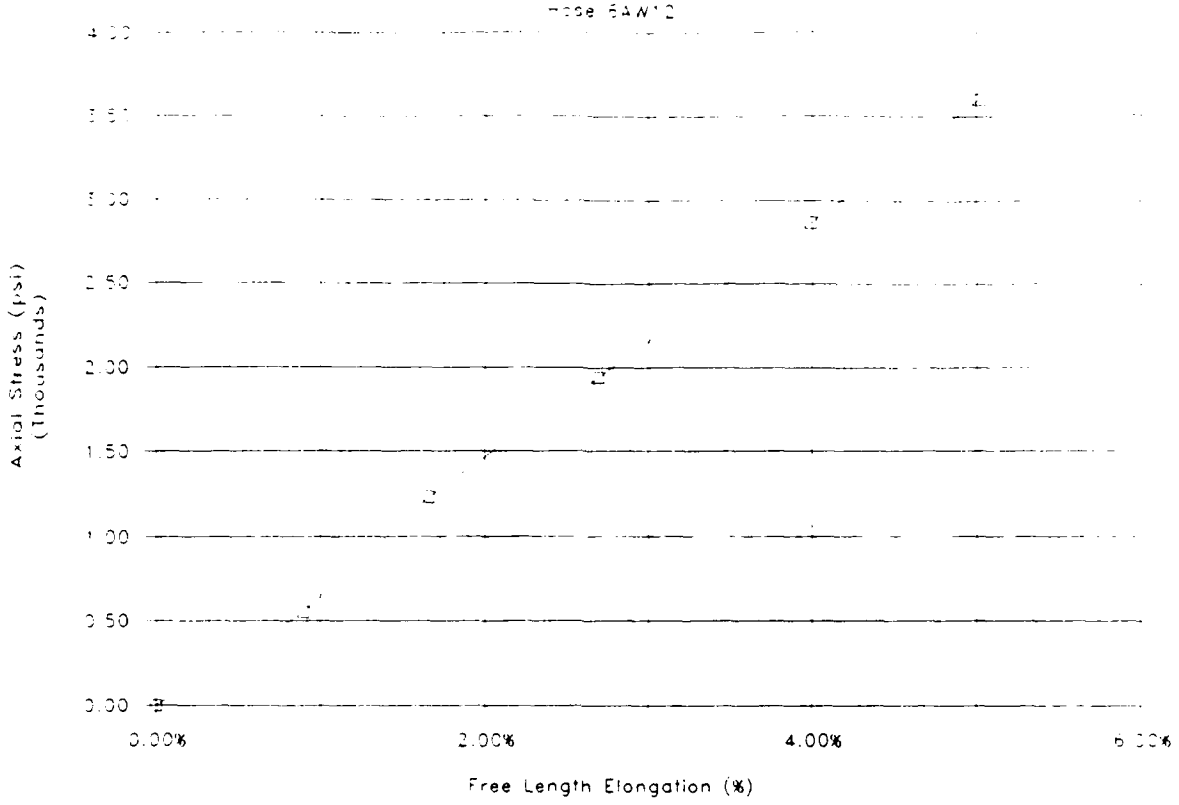
Actual Load (lbs)	Eng. Stress (psi)	Free Length (inches)	Free Length Elongation (%)
0	0.00	139.50	0.00%
2223	553.61	140.75	0.90%
4950	1232.49	141.81	1.66%
7786	1938.61	143.25	2.69%
11520	2868.38	145.06	3.99%
14457	3599.57	146.50	5.02%
0	0.00	140.94	1.03%

Axial Strength Test

	Axial Load (lbs)
Expected Tensile Strength =	44,000
Actual Tensile Strength =	34,592

Axial Stress vs. Elongation

Hose SAW'2



Data Package for Angus Sample 6AW6

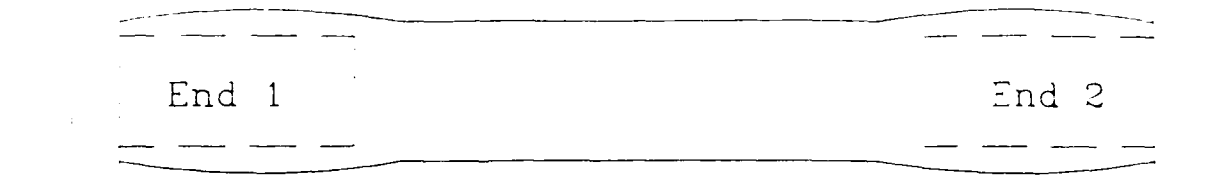
Acceptance Test Data Sheet

Data Sheet No

Hose I.D. Code

cut piece of hose 74" long

Loa = 82 3/4"



N1 = 7 1/4"

N2 = 7 1/4"

Free Length = Loa − (N1 + N2) = 68.25"

Dist from End 1	Outside Diameter
N/A	NONE taken — FLAT HOSE

Signature

Date

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
~~6UF30~~ 6UA30	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
~~6UF30~~ 6UA30	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
~~6UF30~~ 6UA30	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

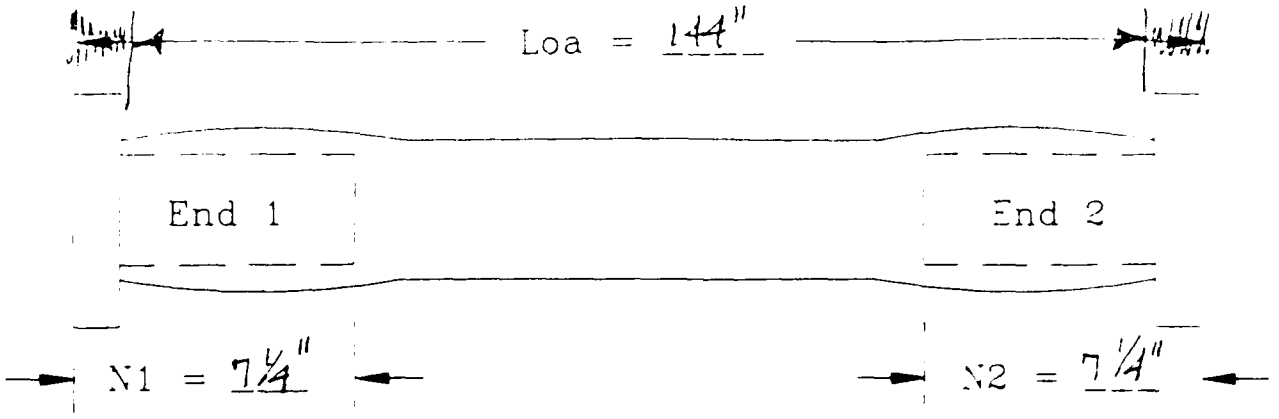
Data Package for Angus Sample 6AP12

DIMENSIONAL

~~Acceptance~~ Test Data Sheet

Data Sheet No. 011

Hose I.D. Code GAF



Free Length = Loa − ~~(N1 + N2)~~ (2 * 2.75) = 138.50"

Dist from End 1	Outside Diameter
N/A	LAY FLAT HOSE

Signature D.W. Johnson

Date 2-28

[illegible] completed & inspected

Kerosene test on 6AW12 — NO ADVERSE INDICATIONS

-No pressure due to leaks —

D.W. Johnson
Joe Carellis

KEROSENE TEST ON 6AP12 — NO ADVERSE INDICATIONS

-No pressure due to leaks at coupling

DW Johnson 11/30/88

completed & inspected on 11/30/88

Test Results Worksheet

Hose 6AP12

Axial Load vs. Elongation Test

Lo = 156.63 "

Nipple = 7.25 "

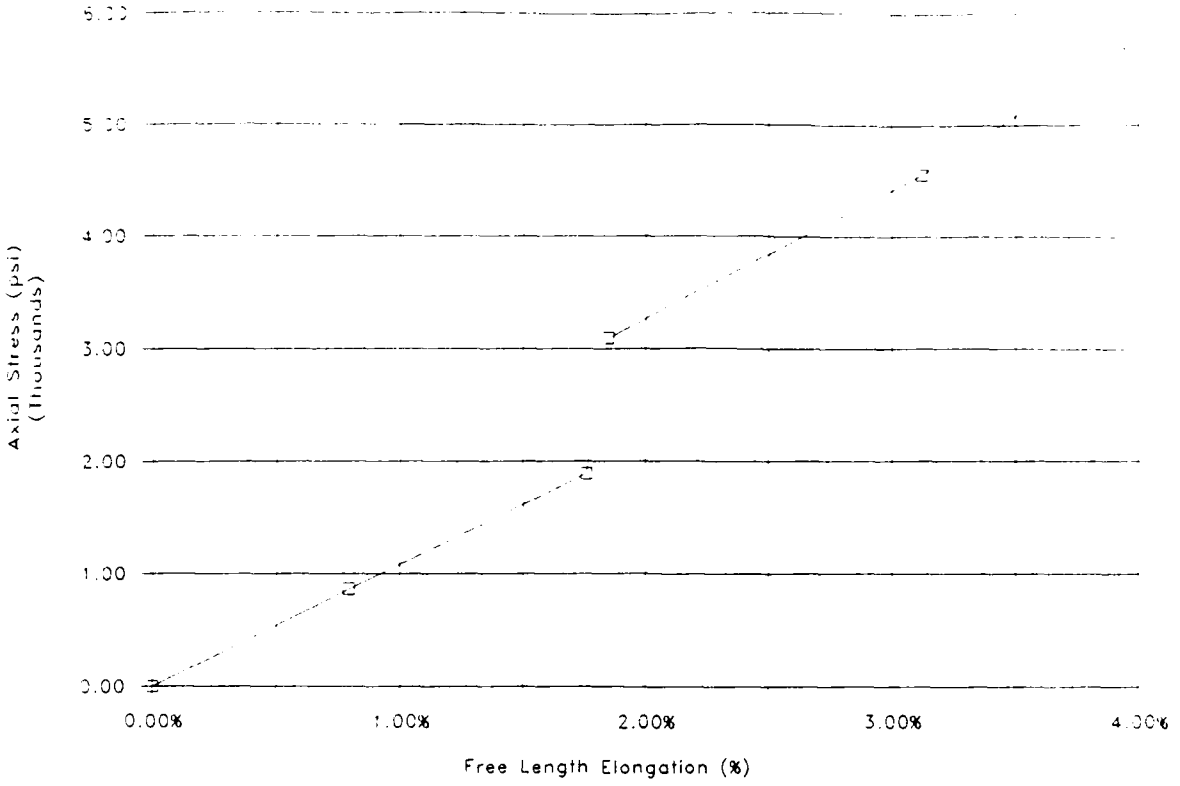
Actual Load (lbs)	Wall Stress (psi)	Free Length (inch)	Free Length Elong (%)
0	0.00	142.13	0.00%
2207	864.71	143.25	0.79%
4824	1889.92	144.63	1.76%
7899	3094.17	144.75	1.85%
11640	4560.02	146.56	3.12%
14600	5719.34	147.75	3.96%
0	0.00	142.38	0.18%

Axial Strength Test

	Axial Load (lbs)
Expected Tensile Strength =	47,000
Actual Tensile Strength =	32,936

Axial Stress vs. Elongation

Hose 6AP12



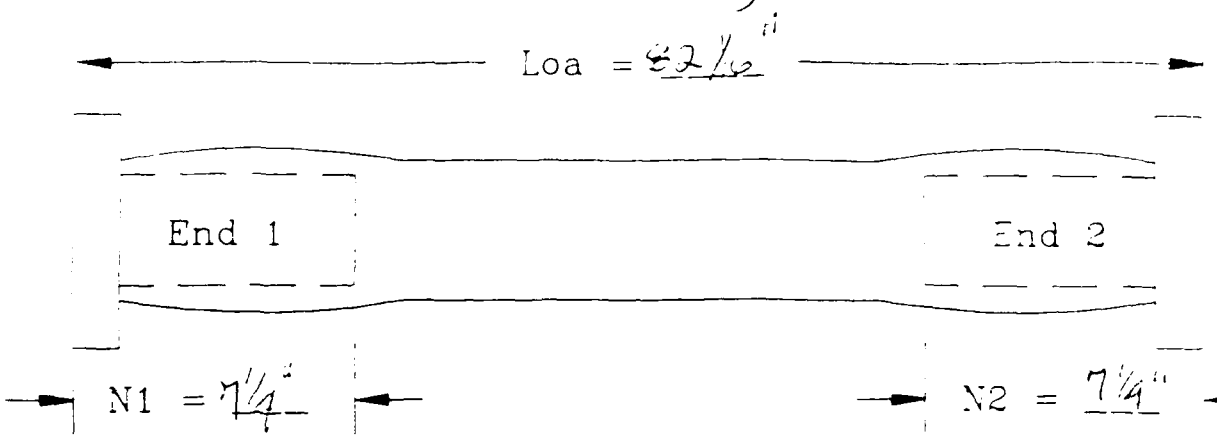
Data Package for Angus Sample 6AP6

Acceptance Test Data Sheet

Data Sheet No

Hose I.D. Size

cut piece of hose " long



Free Length = Loa − (N1 + N2) = 67.563

Dist from End 1	Outside Diameter
N/A	NONE TAKEN —
	FLAT HOSE

Signature D. W. Johnson

Date

Hydrostatic Stability and Burst Test Results

Hose Sample	Lo (inch)	Lp (inch)	Lf (inch)	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	251.13	255.25	251.00	1.64%	600	-0.05%
~~6UF30~~ 6UA30	374.63	371.00	374.75	-0.97%	1066	0.03%
6AW6	n/a	n/a	n/a	n/a	530	n/a
6AP6	83.25	84.63	83.31	1.65%	325	0.08%
8UA12A	143.56	143.75	143.50	0.13%	1066	-0.04%
8P12A	144.50	143.69	144.75	-0.56%	600	0.17%
8UA10	124.69	124.44	124.75	-0.20%	1066	0.05%

Hydrostatic Stability and Burst Test Results

Hose Sample	Growth at Pressure (%)	Test Pressure (PSI)	Residual Growth (%)
6UF20	1.64%	600	-0.05%
~~6UF30~~ 6UA30	-0.97%	1066	0.03%
6AW6	n/a	530	n/a
6AP6	1.65%	325	0.08%
8UA12A	0.13%	1066	-0.04%
8P12A	-0.56%	600	0.17%
8UA10	-0.20%	1066	0.05%

Hose Sample	Minimum Burst Pressure (PSI)	Burst Pressure (PSI)
6UF20	900	797
~~6UF30~~ 6UA30	1600	1836
6AW6	825	487
6AP6	500	464
8UA12A	1600	1695
8P12A	900	2159
8UA10	n/a	n/a

END

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